Hochschule Niederrhein
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Umweltinstitut München e.V.

Deutsche Umwelthilfe

BELLONA

Short study

September 2025

Economic and Business Assessment of Energy Efficiency in Industry

Market-oriented and cost-effective energy saving potential in industry

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Economic and business assessment of energy efficiency in industry

Market-oriented and cost-effective energy saving potential in industry

| Status: September 2025 |

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On behalf of Umweltinstitut München e.V., Deutsche Umwelthilfe e.V. and Bellona Deutschland gGmbH

Summary

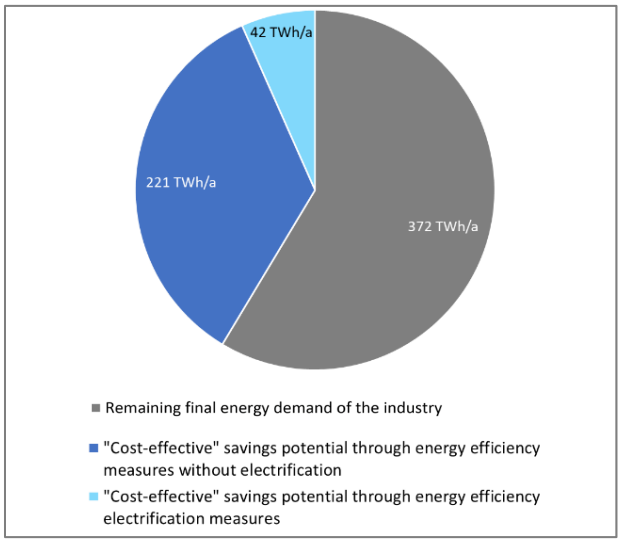
- Energy efficiency makes an important contribution to securing Germany's position as an industrial location: by implementing **cost-effective** final energy saving measures (i.e. measures with a positive net present value), 263 TWh/a of the 635 TWh/a **final energy demand** of German industry (as of 2023), i.e. **around 40%, can be saved**. 209 TWh_{th} /a in the heating sector, 54 TWh_{el} /a in electricity applications.
- A large proportion of the cost-effective final energy saving measures are even **"market-oriented measures",** i.e. they have payback periods of less than 3 years. The associated savings are **around 28%** (176 TWh/a), divided into 134 TWh_{th}/a in the heating sector and 42 TWh_{el} /a for electricity applications outside the heating sector.
- The **cost-effective** final energy savings from all measures would result in **cost savings** of around **€29 billion per annum** in 2025. The necessary **investment** is estimated at a total of **€104 billion**[1], resulting in an average payback period of 3.6 years. Cumulatively over the next 20 years, the total savings for the investment path described in the study amount to approximately €250 billion.
- Added to this are the **economic benefits**: energy efficiency measures not only reduce demand, but also peak loads. If by 2045, 10 GW less gas-fired power plants need to be built, the investment requirement would be reduced by around €10 billion. Added to this are the avoided natural gas import costs of the power plants that were not built, amounting to around €1 billion per year, resulting in a cumulative **economic benefit of €30 billion** over 20 years **for gas-fired power plants alone**.
- Energy efficiency measures also contribute to **security of supply** by reducing the need to import fossil fuels. A further contribution is the support for Germany in meeting its international commitments and thus, where applicable, avoiding specific penalties for the federal government or taxpayers.
- Other positive external effects include: more jobs in Germany, an increase in the value of capital stock, an increase in overall economic productivity and an acceleration of technological progress. Investments in energy efficiency shift capital flows away from abroad (e.g. for the extraction and transport of natural gas) and towards domestic investments in Germany.
- **Typical energy-saving measures** include insulation and, above all, waste heat utilisation. Other measures are improved user behaviour, optimised control, operating and maintenance measures, drives with speed control, highly efficient motors and the usage of free cooling. The renewal of systems was also taken into account, as was the use of environmental heat. The switch to heat pumps is an important measure, particularly in the heat range up to 200°C. The **total savings achieved through the electrification** of processes in heat applications account for around 20% of the savings.
- Potentials for individual companies and industries are of course different. However, even industries with lower absolute final energy requirements, such as the **food industry** (47 TWh/a), show similar results in percentage terms. The measures are only slightly different (e.g. no savings in the high-temperature range, more heat pump measures).
- The **"energy-intensive industry"** accounts for 81% (514 TWh/a) of the final energy demand of German industry, so the results are very comparable to those when considering

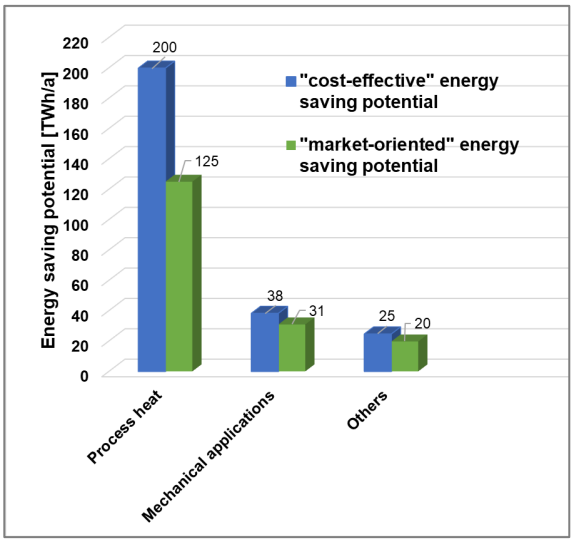
[1] For an assessment of the investment sum, please refer to the evaluation of the "Federal Funding for Energy and Resource Efficiency in the Economy" dated 31 October 2023. The funding commitments from this programme triggered investments of €2.1 billion in 2022. [48]

the industry as a whole. In the case of any concessions for energy-intensive industries, the **definition** should be **standardised** and adjusted so that **thresholds** are **individually adjusted** in line with proven final energy savings.

- Although many companies are aware of the measures, there are **obstacles** to implementing them. In addition to **liquidity constraints**, these include, at the operational level, **a lack of personnel capacity** and the desire for **short payback periods**, rather than a decision based on a net present value analysis.
- Furthermore, investments in energy efficiency are hampered by **additional obstacles** that lie outside the influence of individual companies or even the entire industry. The **political regulatory framework** is a particularly important factor here. Another obstacle may lie in **ownership structures**.
- **Government intervention** should generally be viewed critically, as it usually restricts the efficiency of functioning markets. Since there is clearly a market failure on the market for energy efficiency, i.e. an efficient market outcome has not yet been achieved, there should be an open discussion about how additional government support could promote energy efficiency. Various instruments and levels of intervention are possible.
- An analysis of **subsidies** in the energy sector yields the following results (2026 planning): 13 of the 20 largest financial aid packages, totalling €42 billion, are allocated to the energy sector (over 70%), while tax reliefs still account for €7.7 billion (over 40%). An obvious suggestion would be to scrap the reliefs and subsidies on energy costs and distribute the freed-up funds to energy efficiency promotion measures. This would have the advantage of not requiring any additional federal funds.

Energy saving potentials at a glance:





The diagram on the left shows how significant the savings are in relation to the total final energy demand and how much electrification of heating applications accounts for. The diagram on the right shows the cost-effective and market-related savings potential for the various application areas.

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Introduction

The pressure to take action on industry, and in particular on energy-intensive industry in Germany, is very high in 2025. The industrial sector in Germany is responsible for the largest share of CO_2 emissions, taking direct and indirect emissions into account. Climate policy requirements, challenging energy prices and a complex regulatory landscape are forcing companies to make extensive investments in energy efficiency technologies and electrification. Industries with high energy requirements, such as the metal, chemical, paper and food industries, are particularly affected, where the exploitation of technical and cost-effective savings potential is increasingly becoming a key competitive factor. Reducing energy demand and energy costs and switching to CO_2-free production (often referred to as "decarbonisation") have therefore become a "must" for every company. For some industries, there are also process-related emissions that must be avoided, e.g. through storage. This may even lead to an increase in final energy demand.

The motivations for energy-saving measures in industry vary: whether it is to generate competitive advantages, meet supplier requirements, improve environmental image or comply with legal requirements. Against this backdrop, the development of electricity prices for industrial consumers is also becoming particularly important. Contrary to the widespread assumption that promoting renewable electricity generation will inevitably lead to rising costs, a recent study by Agora Energiewende (2025) [1] shows that the consistent expansion of wind and solar energy can lead to a significant reduction in the average electricity exchange price. This analysis [1] predicts that by 2030, a decline of up to 23% can be expected compared to a less ambitious expansion path. Whether the industrial electricity price will also fall depends on the development of grid fees, taxes, levies and surcharges [1], [2], [3]. The European

Commission's Action Plan for Affordable Energy [4] also anticipates falling prices and aims to support this with eight concrete, short-term measures.

This opens up new perspectives for energy-intensive process heat generation: falling electricity production costs increase the attractiveness of electrified processes and make the use of fossil fuels increasingly uneconomical if the price of fossil fuels remains the same or rises. This creates additional incentives for companies to actively shape the transformation process and tap into further savings in energy and CO_2 emissions, particularly through electrification strategies [1]. Although electrification leads to higher electricity demand, it reduces overall final energy demand.

Germany's final energy demand in 2023 was at its lowest level in decades. In addition to the energy efficiency measures already implemented and the expansion of renewable energies, the decisive factor here is Germany's economic situation. In 2024, there was a slight increase in final energy demand in Germany from 2,251 TWh in 2023 to 2,255 TWh in 2024[2]. [5], [6]

This brief study, "Economic and business assessment of energy efficiency in industry," aims to demonstrate that investments in energy efficiency measures are economically advantageous for companies. Its methodology and evaluation are based on the studies conducted for DENEFF in 2023 [7] and 2024 [8]. In addition to these studies, the data has been updated and the "energy- intensive industry" and the food industry are examined in more detail. Furthermore, an economic assessment is carried out and the effect of electrification (energy source change) is considered separately in the energy-saving measures.

First, this study defines key terms and the scope of energy-intensive industry, as many cost-effective energy-saving opportunities have not yet been implemented in this sector. The chapter "Increasing energy efficiency in industry" then identifies and evaluates cost-effective and market-oriented savings potential. This includes a classification of the most important final energy applications and process heat areas, as well as a specific examination of the food industry. In the process heat sector, a distinction is made between general measures to reduce final energy demand and "electrification measures" (energy source conversion). Subsequently, and in the appendix, specific energy efficiency measures and their potential are described, and the implementation of these measures is evaluated in terms of their operational and economic impact. Finally, the last chapter presents the most important obstacles to implementation and suggests solutions for overcoming these obstacles. Subsidies in the energy sector are also included. A brief conclusion rounds off this short study.

Definition of “energy-intensive industry”

"Energy-intensive industry" is considered separately, as a very large proportion of subsidies flow into this sector (see below). Increasing energy efficiency and thus reducing final energy demand in these industries would have a major economic advantage in addition to the operational benefits for companies.

The classification of a company as "energy-intensive" is not clearly defined or specified, but is rather determined by a dynamic and context-dependent perspective. In practice, there are a variety of definitions. [9], [10], [11], [12]

Industries such as chemicals, metals, paper, cement, lime, ceramics and glass are generally considered to be energy-intensive because they have a high absolute final energy demand for

[2] The figures for 2024 were not yet available at the start of the brief study. However, the results are easily transferable, as Germany's final energy demand in 2024 has hardly changed compared to 2023.

the manufacture of their products or very high energy costs. Various regulations and support measures also take into account certain quantitative limits, such as a specific annual final energy demand or annual energy costs as a proportion of gross value added.

However, the various approaches lead to individual challenges: if classification is based solely on absolute total final energy demand, only large industrial sectors such as metal production and processing or the chemical industry and large industrial companies are normally considered energy-intensive. This carries the risk of misclassification: (1) Companies may be incorrectly classified as energy-intensive based on their industry, even though their actual energy demand and energy intensity are not high. (2) When smaller businesses – often SMEs[3] – or sectors such as the food industry are overlooked, even though energy costs often account for a very high proportion of production costs in the food industry. It can also lead to important businesses being excluded from support programmes or regulatory obligations, even though they do not reach the thresholds specified in the regulations despite the high energy intensity of their production.

The different approaches to definitions also present additional difficulties. Differences in industries and technologies, fluctuating energy costs and continuous innovation can mean that companies fall into or out of the "energy-intensive" category depending on the situation. Rigid boundaries can lead to companies that are just above or below a certain value experiencing misguided incentives or economic disadvantages, regardless of their actual energy efficiency or economic significance. The ambiguities show that a definition based solely on absolute demand values or membership of a particular industry does not adequately represent the actual energy intensity of an industrial company. For this reason, scientists and practitioners are increasingly proposing a more precise analysis based on relative indicators such as the share of energy costs in gross value added or production costs in order to enable a more comprehensive and fairer assessment.

According to EU Energy Tax Directive 2003/96/EC [10] companies are considered energy-intensive if their annual energy costs amount to at least three per cent of their production value or if the national energy tax payable amounts to at least 0.5 per cent of the added value. This definition establishes a practical regulatory framework, but leaves room for individual adjustments at national and sector-specific level. It therefore makes more sense to use a flexible and context- dependent approach involving various criteria in order to measure the actual energy intensity of companies appropriately. This allows both typical sectors and sub-sectors of the food industry to be included.

The authors propose using the definition in EU Energy Tax Directive 2003/96/EC as a uniform basis for all businesses and industries, but reducing the threshold individually each year so as not to hinder the implementation of energy efficiency measures, since implementation leads to a reduction in energy costs and thus to a fall below the threshold[4]. The threshold would be reduced individually in line with the proven final energy savings.

[3] SME = Small or medium-sized enterprise (see EU Recommendation 2003/361)

[4] Simplified example: Energy €950,000/a, production value €30 million/a → 3.20% > 3.00% (threshold value). After implementation of energy efficiency measures: Energy €880,000/a, production value €30 million/a → 2.93%. This is < 3.00%, meaning the company is no longer energy-intensive. Therefore, adjustment of threshold value to 2.93%/3.20% = 0.92 and 0.92*3% = 2.76%. With 2.93% > 2.76, companies remain energy-intensive.

Increasing energy efficiency in industry

After a brief explanation of the methodology used here, the potential for individual areas of application in industry is described in concrete terms and illustrated.

Methodology

A large part of the final energy used in the industrial sector, amounting to 635 TWh/a (2023)[5] will still be needed in the future to manufacture products [13]. The percentage of this final energy consumption that will be reduced in the future depends on the state of the art, the decision-makers' knowledge of the technical possibilities, energy prices and political and economic conditions (including desired returns and investment risk).

From a purely technical perspective, the future final energy demand of industry can be estimated very accurately. As in both studies [7] and [8], this study also distinguishes between three types of potential:

- the final energy saving potential, i.e. the possibilities for reducing electricity, fuel and heat consumption;
- the potential for reducing end-use energy costs, i.e. the possibilities for reducing the costs of electricity, fuel and heat, and
- the investment sums required to implement the above-mentioned potential, which from the perspective of solution providers can also be referred to as market potential.

Potential is also determined for various framework conditions:

- "Total potential": All possible measures are added together – regardless of whether the measure is cost-effective or not. In the case of measures that influence each other measures, the savings of the individual measures are weighted (this also applies to the other two potentials).

  “Cost-effective potential”: This only includes measures that are economically viable over their useful life, i.e. the net present value[6] of the energy efficiency measure is positive. In this case an 8% return on equity, standard individual useful lives and price trends for electricity and heat are assumed. The electricity price until 2029 is based on EEX baseload prices[7], i.e. between 2025 and 2029, an average exchange price of €93/MWh is assumed, from which a company electricity price of €181/MWh is derived. From 2030 onwards, falling exchange prices and rising grid fees are assumed. A similar approach is taken for the natural gas price: THE calendar year prices are used as a basis until 2029[8]. The heat price until 2029 is composed of the distribution of process heat in energy sources according to [13]: 7.7% electricity, 50.1% natural gas, 3.0% oil, 23.2% coal and 16.0%

[5] This study uses data from the Federal Statistical Office [25] for the year 2023, and all energy sources used for energy purposes except geothermal and environmental heat for heat pumps and solar thermal energy are considered final energy. The double counting of fuels for electricity generation in own plants and the electricity generated [50] is adjusted using data from the Federal Statistical Office on own electricity generation [49] and AGEB evaluations on combined heat and power in industry [51].

[6] The economic efficiency of a measure is assessed using the net present value (see VALERI standard [42]. An internal interest rate of 8% and individual useful lives (including Afa tables) are assumed. The interest rate was varied between 4% and 12%. The impact on the results is so minor that the scenarios are not presented in detail in this study.

[7] Electricity prices are based on the EEX front-year baseload values for 2026 to 2029 as of 25 August 2025, plus 6.0 ct./kWh grid fees, 2.8 ct./kWh levies and surcharges (including 0.05 ct./kWh taxes).

[8] Natural gas prices are based on THE calendar year values from 2026 to 2029 as of 25 August 2025, plus 1.14 ct./kWh grid fees and 3.11 ct./kWh levies, surcharges and taxes.

heat. The heat price for 2060 takes into account a new breakdown of energy sources (80% electricity, 20% heat) and a corporate electricity price of €195/MWh.

- "Market-oriented potential": This takes into account the fact that cost-effective measures are generally only implemented if the required static payback period (here: three years [9]) is met. The "market-oriented potential" is part of the "cost-effective potential".

For a more detailed explanation of the methodology used, please refer to studies [7], [8] and [15]. These studies also contain graphical representations and explanations of the methodology used to determine the potential. The underlying assumptions regarding the savings measures taken into account in the calculations (savings potential, savings potential already implemented, investment sum, payback periods, etc.) are based on empirical values and values found in the literature. By summing up all relevant technologies and the areas of application considered, it is possible to determine the total, cost-effective and market-oriented potential of the industry for Germany. The areas of application considered are "motion" (pumps, fans, blowers, motors, drives, machines, etc.), compressed air, process cooling, air conditioning, lighting, IT, space heating, hot water and process heat. These areas have been grouped into three categories in the graphs: (1) process heat, (2) mechanical applications ("motion", compressed air, process cooling, air conditioning) and (3) other (space heating, hot water, IT, lighting).

Various temperature ranges are considered for process heat. The analysis begins with a consideration of the waste heat utilisation cascade, thus following the principle "Efficiency first" is followed, which is mentioned in various studies [14], [15], [16] or [17] and also in Directive 2012/27/EU (Energy Efficiency Directive, EED) in Article 1, sentence 3. The waste heat utilisation cascade comprises measures to avoid waste heat, heat recovery/integration and internal and inter-company waste heat utilisation [25]. In addition, renewable heat sources such as solar or geothermal energy are considered as measures in the appropriate temperature ranges. Finally, alternative technologies and processes for process heat supply (e.g. electrification) are included. Representative technologies are selected for industries that are heavily represented in a temperature range and replaced by the most energy-efficient alternative technology. The compilation of measures and alternative technologies takes into account various studies [7], [15], [16], [17], [18], [19], [20], [21], [22] and [23].

When determining the final energy saving potential, the proportion of measures already implemented is estimated for each measure and deducted from the saving potential. In particular, this takes into account the fact that some companies already have an established energy management system.

Since the measures influence each other, the savings of the individual measures are weighted and, depending on the area of application, a savings potential is shown as a percentage. This percentage value and the final energy demand according to [24] are used to determine the savings potential in TWh/a for the individual areas of application. After standardising the individual percentage values of the measures within an application, the savings potential in TWh/a for the measures in the individual areas of application can then be calculated. This illustrates which measures in the individual areas of application can be used to tap into savings potential.

[9] However, even a static payback period of three years or less does not guarantee implementation, as other non-economic obstacles such as preference structures, etc. may stand in the way (see section on obstacles further on in the text).

The next step is to determine or estimate a short and a long average payback period for each measure. The two payback periods are weighted according to frequency. The necessary investment sum (= market potential) is then determined using the energy cost reduction potential and the payback periods. By adding up the sums for the areas of application and, in the case of process heat, also for the individual temperature ranges, it is then possible to determine both the cost-effective and market-oriented energy saving potential of industry for Germany.

As explained above, different temperature ranges are considered for process heat. The savings from the individual measures are offset against each other in such a way that a savings potential in percent is shown for each temperature range. This percentage value and the final energy demand according to [24] are used to determine a savings potential in TWh/a per temperature range. After normalising the individual percentage values of the measures within a temperature range, the savings potential in TWh/a for the measures in the individual temperature ranges can then be calculated. The cost-effective energy cost reduction potential is then determined using the assumed heat price development. The necessary investment sums (market potential) are determined in the same way as for the other areas of application.

Despite conscientious analysis methods and due care and thoroughness in the various evaluations, there remain some points that require critical assessment with regard to the significance and reliability of the results. The final energy saving potentials determined always refer to German industry as a whole. At the level of individual companies, the relative potentials vary depending on the industry, type of production, implementation status of energy efficiency measures, existing infrastructure, etc. With regard to payback periods, it is also entirely possible that the capital invested will be recouped more quickly or more slowly than assumed here in the case of individual companies. Furthermore, the setting of energy prices has a major influence (differences depending on company size and energy requirements). This also has a particular influence because the timing of the implementation of the measures is not taken into account (depending on the modernisation cycle of individual plants). Further explanations of assumptions, data basis and methodology are provided in Appendix 1.

Description of specific measures and associated final energy saving potential

Appendix 2 describes in detail specific technical and organisational measures for increasing energy efficiency. These include, for example (the order of the list is roughly based on the ascending investment costs of the measures):

- Improved user behaviour
- Insulation of pipes, fittings, machines | Protection against heat input or heat loss
- Operating and maintenance measures: Hydraulic balancing, elimination of compressed air leaks, cleaning of heat exchanger surfaces, etc.
- Optimised control: Adjustment of parameters (temperature, pressure, etc.), adjustment of operating times and operating modes (full load, partial load, etc.), drives with variable speed control, energy recovery, automation and use of artificial intelligence (AI)
- Heat recovery, free cooling
- Use of environmental heat (especially via heat pumps, solar thermal energy where applicable)
- Heat: Electrification
- System renewal: Use of energy-efficient, demand-adapted new systems (machines, devices, lighting, etc.) | Use of highly efficient motors

- Modernisation/reduction of transmission heat losses (windows, walls, roof, etc.)

The industrial sector in Germany required 635 TWh of final energy in 2023[10] [25]. This was divided into 190 TWh$_{(el)}$ of electrical energy and 446 TWh$_{(th)}$ of fuel and heat. In particular, the application areas of "process heat" (steam, direct fuel use in dryers or furnaces, etc.) with 426 TWh (67%) and "motion" (pumps, fans, blowers, motors, drives, machines, etc.) with 122 TWh (19.2% of total energy demand or 65% of demand for electricity applications outside the heat sector) account for a large proportion of total energy demand in industry and thus offer considerable potential for energy savings. [25]

The analysis conducted as part of this study has shown that the cost-effective energy saving potential (i.e. implementation of measures with a positive net present value) amounts to approximately 40% of the final energy demand of German industry, which stands at 635 TWh, or 263 TWh/a. This potential comprises 209 TWh$_{th}$/a in the heating sector and 54 TWh$_{el}$/a for electricity applications outside the heating sector. Based on the assumed energy price development, the cost savings from implementing all cost-effective measures amount to €29 billion/a. The calculated investment sum for the measures to tap this potential is €104 billion[11] in total, resulting in an average payback period of 3.6 years.

Figure 1 shows the aggregated cost-effective final energy saving potential of 263 TWh/a across all application areas mentioned above, as well as the market-oriented final energy saving potential of 176 TWh/a. The figure also shows how much the measures (in percent) in the various application areas contribute to the total potential.

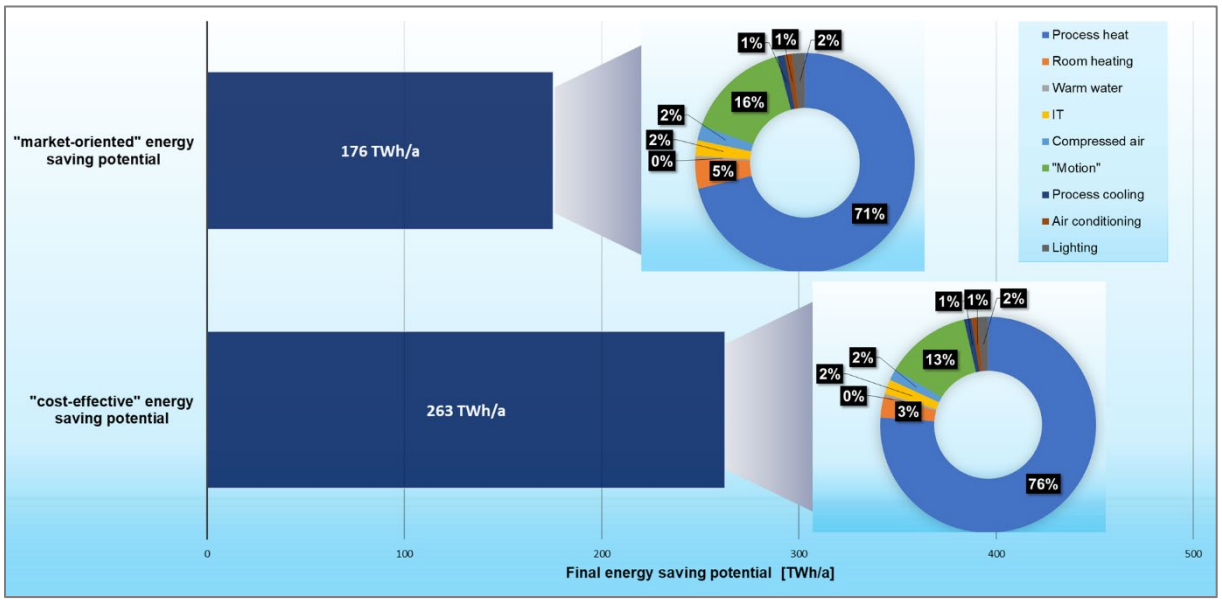

Figure 1: Total annual final energy saving potential in industry in TWh/a and breakdown by application area in per cent.

[10] The figures for 2024 were not yet available at the start of the brief study. However, the results are easily transferable since, as mentioned above, Germany's final energy demand in 2024 has hardly changed compared to 2023.

[11] For context: total gross investment in Germany amounted to €906 billion in 2024. Taking depreciation into account, net investment amounted to €19 billion. It should be noted that net investment in 2024 was at a very low level. In the previous 10 years, the figure ranged between €51 billion and €122 billion per year. [47]

176 TWh/a market-oriented final energy saving potential compared to 263 TWh/a cost-effective final energy saving potential means that, due to a payback period of more than three years, an energy saving potential of just under 88 TWh is likely to be realised annually in the industry would not be tapped, even though this would be feasible with cost-effective measures (positive net present value). The implementation of market-oriented energy saving potential (included in the cost-effective energy saving potential) would correspond to approximately 28% of the final energy demand of German industry (= 176 TWh/a), divided into 134 TWh_{th}/a in the heating sector and 42 TWh_{el}/a for electricity applications outside the heating sector.

Figure 2 below illustrates that the application areas of "process heat" and "mechanical applications" in particular offer very large cost-effective and market-oriented energy saving potential in the industrial sector.

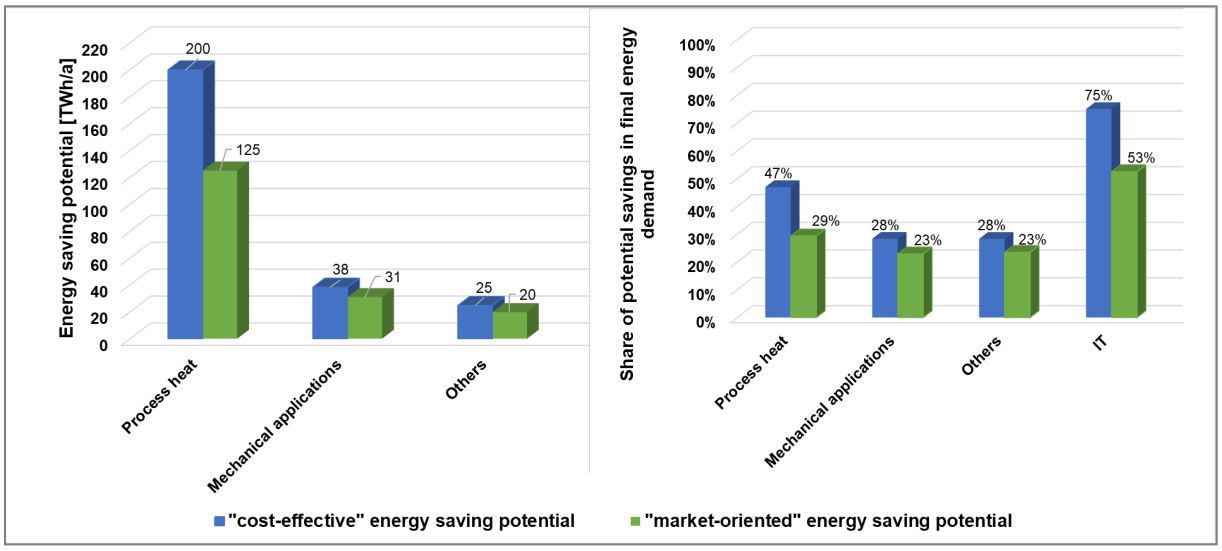

Figure 2: **"Cost-effective" and "market-oriented" energy saving potential in TWh/a for the areas of application in comparison (left diagram). The right-hand diagram shows the percentage savings in relation to the final energy demand of the areas of application.**

Figure 2 also shows, among other things, that the difference between "cost-effective" and "market-oriented" energy saving potential is greatest in the area of process heat. One reason for this is the comparatively high investments [12] that often have to be made for energy efficiency measures in this area of application.

Another interesting finding is that more than 20% of final energy can be saved in all areas of application (right-hand side of Figure 2). In the area of information and communication (IT), the figure is even over 50%.

The largest share of cost-effective energy savings in the area of process heat is achieved by measures such as "insulation of pipes, fittings, machines and buildings" and, above all, the operational "use of waste heat" through heat recovery. Other important measures here are "improved user behaviour" and "optimised control (adjusting parameters, etc.)" as well as "operational and maintenance measures: hydraulic balancing, cleaning of heat exchanger surfaces, etc.". The electrification of processes (energy source change) can also lead to a reduction in final energy demand, e.g. through the use of heat pumps (see below). However, some of the electrification measures considered here to achieve the 80% electricity share for

[12] Another reason is that fuel and heat prices have historically been low and significantly cheaper than electricity prices.

calculating the heat price for 2060 are not energy efficiency measures, but may even increase final energy demand.

The first measures mentioned are very conducive to electrification, as they reduce the amount of electricity required: less heat demand means less electricity for electrification. These efficiency measures (e.g. measures to avoid waste heat, heat recovery/integration and waste heat utilisation) should therefore be implemented as a matter of high priority, and energy efficiency should always be taken into account in electrification measures. This reduces the amount of heat that must be provided by electrical heat supply (electrification) and also the size of the plant and the associated investment costs.

To put the estimated 200 TWh_{th}/a savings in the area of process heat into perspective, it is interesting to compare this with the amount of heat reported to the “Plattform für Abwärme” (PfA). The 243 TWh_{th}/a reported to the PfA by over 3,000 companies by 29 July 2025 is of the same order of magnitude [26]. However, the values are not directly comparable, as different amounts of heat are considered.

Only waste heat quantities that cannot be used at the time of reporting are reported to the PfA. And those that exceed certain thresholds. In addition, only companies with an average total final energy consumption > 2.5 GWh/a are required to report to the PfA. And the companies required to report are not only industrial companies. Approximately 67% of the waste heat quantities mentioned here have a temperature of less than 60°C [26].

This study took into account all industrial companies, including those with an average total final energy consumption of less than 2.5 GWh/a, and all waste heat quantities (including diffuse waste heat and without threshold values) that can be used economically. Waste heat quantities below 60°C were defined as usable in the study, as heat pumps can raise the temperature to a usable level and thus replace process heat generated by fossil fuels of up to 200°C.

Figure 3 shows the total cost-effective final energy saving potential of 263 TWh/a, divided into 209 TWh/a (42 TWh/a + 167 TWh/a) final energy savings in the heating sector and 54 TWh/a in electricity applications without heating. The savings in the heating sector are broken down into savings per temperature range and savings through electrification.

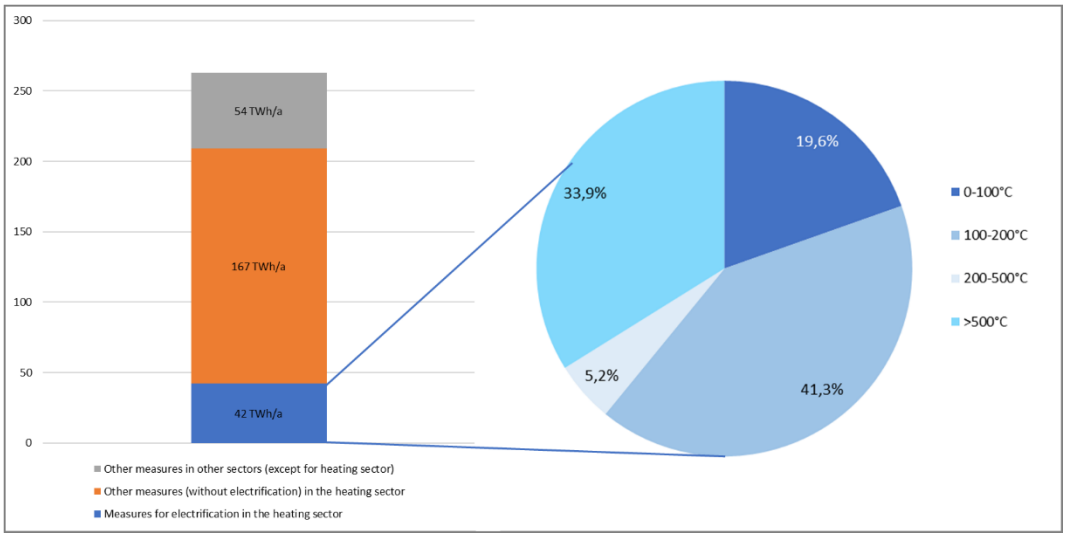

Figure 3: Left diagram: "Cost-effective" savings potential through electrification (blue) compared to other measures in the heating sector (orange) and to all measures (grey). The right diagram shows the percentage distribution of the savings potential through electrification (42 TWh/a) across different temperature levels.

The electrification of processes accounts for around 20% of energy savings in the heating sector (42 TWh/a), as in many cases electrification only results in minor savings in final energy consumption (merely replacing natural gas etc. with electricity). The exception here is the heat pump mentioned above, which significantly reduces final energy demand, as most of the energy comes from free environmental heat or waste heat. The installation of heat pumps leads to savings of 50% to 85% per measure – but is usually associated with high investments and is often not cost-effective at the prices assumed in this study. The right-hand diagram in Figure 3 shows that the savings potential in the ranges from 0°C to 100°C and 100°C to 200°C is greater than in the two ranges > 200°C. Heat pumps can be used in the range up to 200°C. In total, around 22 TWh/a of the 42 TWh/a can be saved through heat pump applications.

Processes involving temperatures of more than 200°C are predominantly found in energy-intensive industries. It is appropriate here to briefly address the topic of process emissions. In addition to CO_2 emissions from the combustion of fossil fuels, CO_2 emissions from processes in these industries are also present. Reducing/avoiding these emissions can also lead to higher final energy demand. However, this will not be considered further here.

Figure 4 below shows the same information as the right-hand diagram in Figure 3. However, the chemical (basic chemicals), metal production and stone & earth sectors are shown in comparison with the other sectors. It can be seen that in the chemical (basic chemicals), metal production and stone & earth industries (left pie chart in Figure 4), a large proportion of the final energy savings are in the range above 500°C – largely due to process changes or new plants. Increased demand due to the avoidance of process emissions (see note above) was not taken into account. The large final energy savings in the areas up to 200°C in the other sectors (right-hand pie chart in Figure 4) are due in particular to the switch to heat pumps.

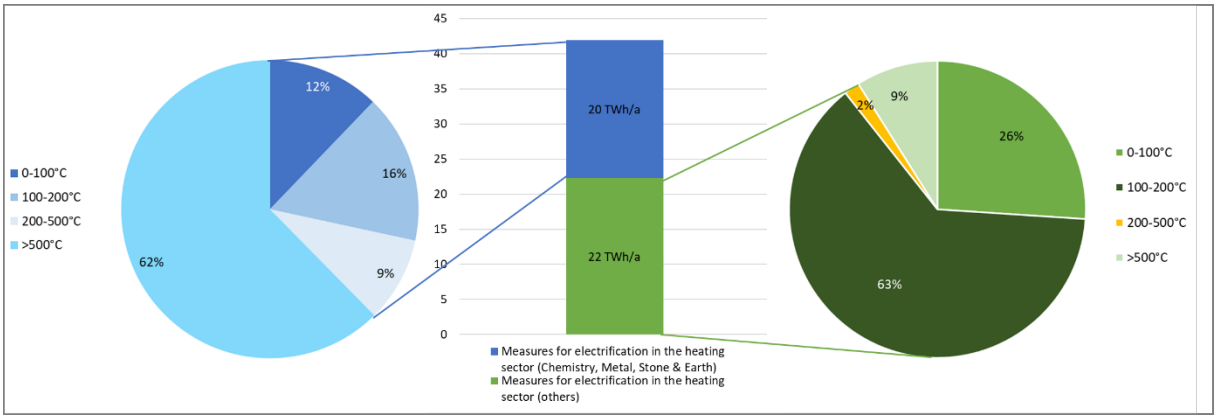

Figure 4: **Final energy saving potential through electrification in the heating sector in the chemical, metal production and stone & earth industries compared to the saving potential through electrification in the heating sector in the remaining industries. Both include a breakdown into four temperature levels.**

Economic evaluation of the measures

At this point, it should be emphasised once again that all the results listed here are heavily dependent on the assumptions (prices, investment sums, interest rates, etc.) in the model. A consideration of the monetary savings potential in billions of euros per year is shown in Figure 5. As described above, the areas of application have been summarised here in three groups.

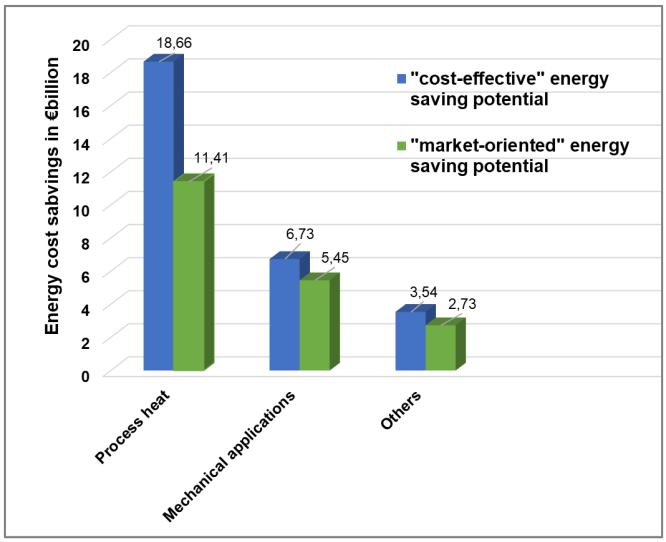

Figure 5: Comparison of "cost-effective" and "market-oriented" energy cost savings potential in billion €/a for the areas of application.

Figure 5 shows that measures relating to electricity applications are becoming increasingly relevant. For example, the market-oriented energy cost savings in the "mechanical applications" group are around 50% of the savings in the "process heat" group. In terms of final energy savings, the share is only 25% (see Figure 2). The reason for this is the significantly higher price of electricity compared to the price of heat in the first years considered.

Figure 6 shows the cost-effective savings potential, the savings potential for the various areas of application (size of circles and numerical value in TWh/a), the investment sum (= market potential) in billion euro (x-axis, logarithmic) and the assumed average payback period (y-axis). Here, too, the large energy saving potentials in the application areas of "process heat", "motion" and "space heating" in the industrial sector are also clearly shown here.

Another result of the calculations in this brief study is that a total investment of around €40 billion is required to tap the above-mentioned market-oriented energy saving potential of around 176 TWh/a. In the case of individual companies, it is entirely possible that energy efficiency measures with longer payback periods will also be implemented. However, it cannot be assumed that this is currently happening on a broad scale.

Based on the measures identified, typical payback periods, investment amounts and cost-effective savings potential are presented. The assessment is made from a business perspective, assuming realistic energy prices and rates of return on capital (see above). The aim is to highlight the attractiveness of the measures for individual companies.

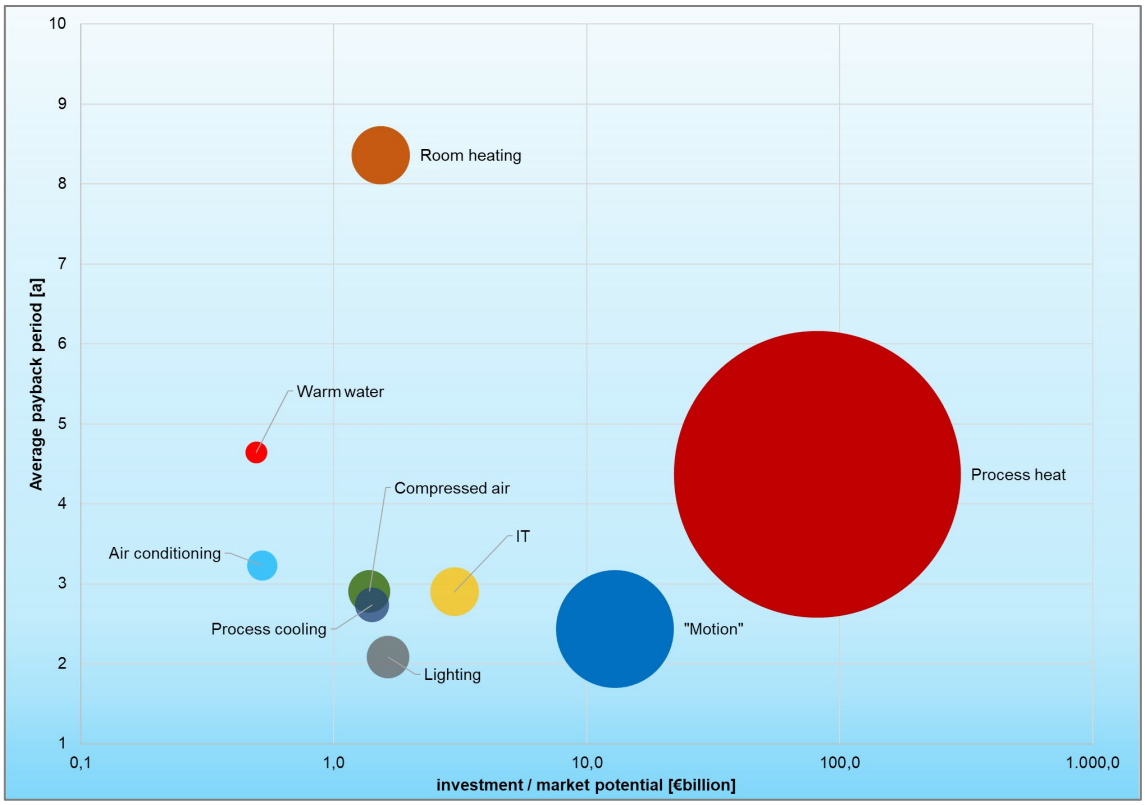

Figure 6: Cost-effective final energy saving potential, average payback periods and investment volumes by area of application in industry

Figure 7 shows a possible investment path and the resulting savings.

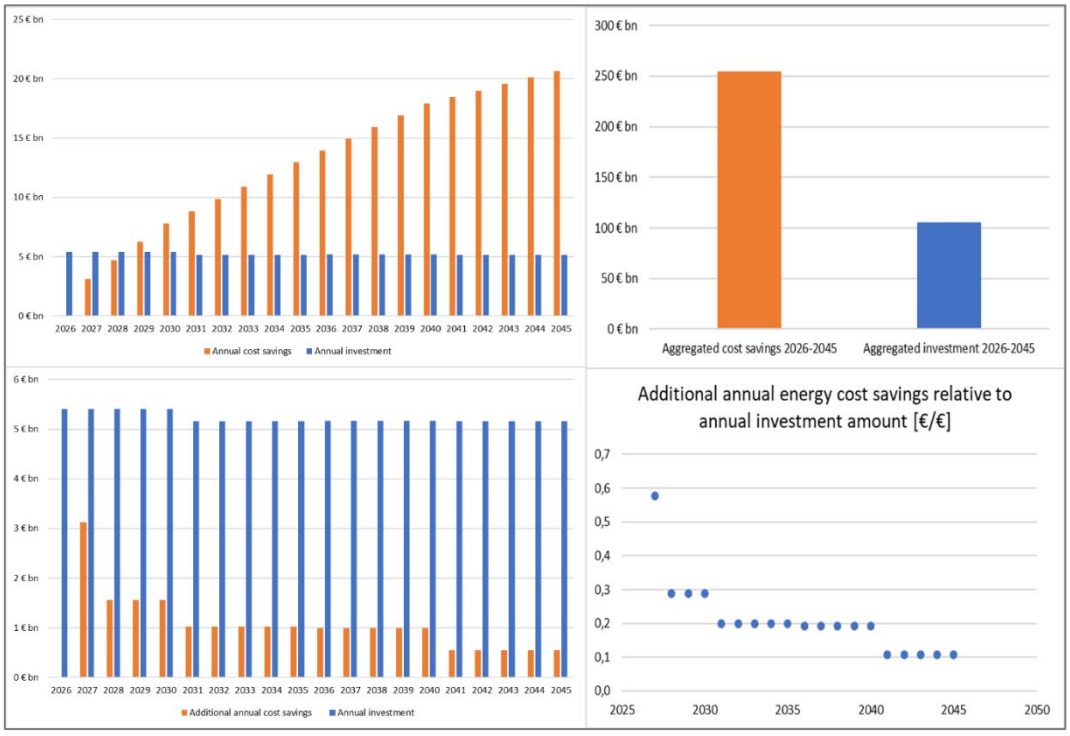

Figure 7: Possible investment path in billion euros and resulting energy cost savings for German industry in billion euros per annum.

For the investment path, measures are divided into the following three groups: (1) measures with a short average payback period (≤ three years), (2) measures with an average payback period between short and long (up to seven and a half years) and (3) the remainder of the cost-effective potential. It is assumed that by 2030, 60% of the measures from group (1), 15% of the measures from group (2) and 2.5% of the measures from group (3) will have been implemented. Further assumptions are made for 2035, 2040 and 2045. Each year of these periods is allocated 20% of the period investment.

The diagram at the top left shows the annual investments in billion euros (blue) and the annual savings, including savings from investments made in previous years, in billion euros (orange) for the period 2026–2045. The graph shows that, as early as 2029, the energy cost savings resulting from investments made between 2026 and 2029 will exceed the projected investment sum for 2029.

The values for the period are added up in the top right-hand corner of the diagram. Looking at the entire period from 2026 to 2045, it becomes even clearer how lucrative the implementation of energy efficiency measures is. Although a total investment of €104 billion is necessary to achieve the nearly 50% final energy savings in industry, this €104 billion is offset by energy cost savings of €254 billion.

The diagram at the bottom left of Figure 7 shows the investments and only the savings for the investment year. The diagram at the bottom right shows the annual savings in euros per annual investment amount in euros. These two lower figures illustrate the degressive trend in cumulative savings (see top left) and thus also show that later savings require specifically higher investments, so that later investments only bring relatively small additional volume or cost savings.

Consideration of a selected industry sector (food industry)

Comparable statements can also be made for individual industries. The results are shown in Figures 8, 9 and 10 as examples for the German food industry[13]. The food industry accounts for slightly more than 10% (29 TWh/a) of the total cost-effective final energy savings potential (263 TWh/a). The special feature here is that not the entire industry is considered energy-intensive. However, the situation is quite different for some sub-sectors and companies: energy costs are a significant factor, which means that the implementation of energy efficiency measures is also very important in this industry.

Figure 8 shows the "cost-effective" and "market-oriented" final energy saving potential in TWh/a for the application areas or groups in comparison (diagram top left), the percentage savings in relation to the final energy demand of the application areas (diagram top right) and the cost-effective final energy saving potential, the average payback periods and the investment volumes by application area (diagram below). It is clear to see that in the food industry, too, the application areas "process heat" and "mechanical applications" in particular offer very large cost-effective and market-oriented energy saving potential.

[13] Based on the available data, the short study "Production of food and feed" "Beverage production" and "Tobacco" have been combined so that the figures from GENESIS and UBA are consistent.

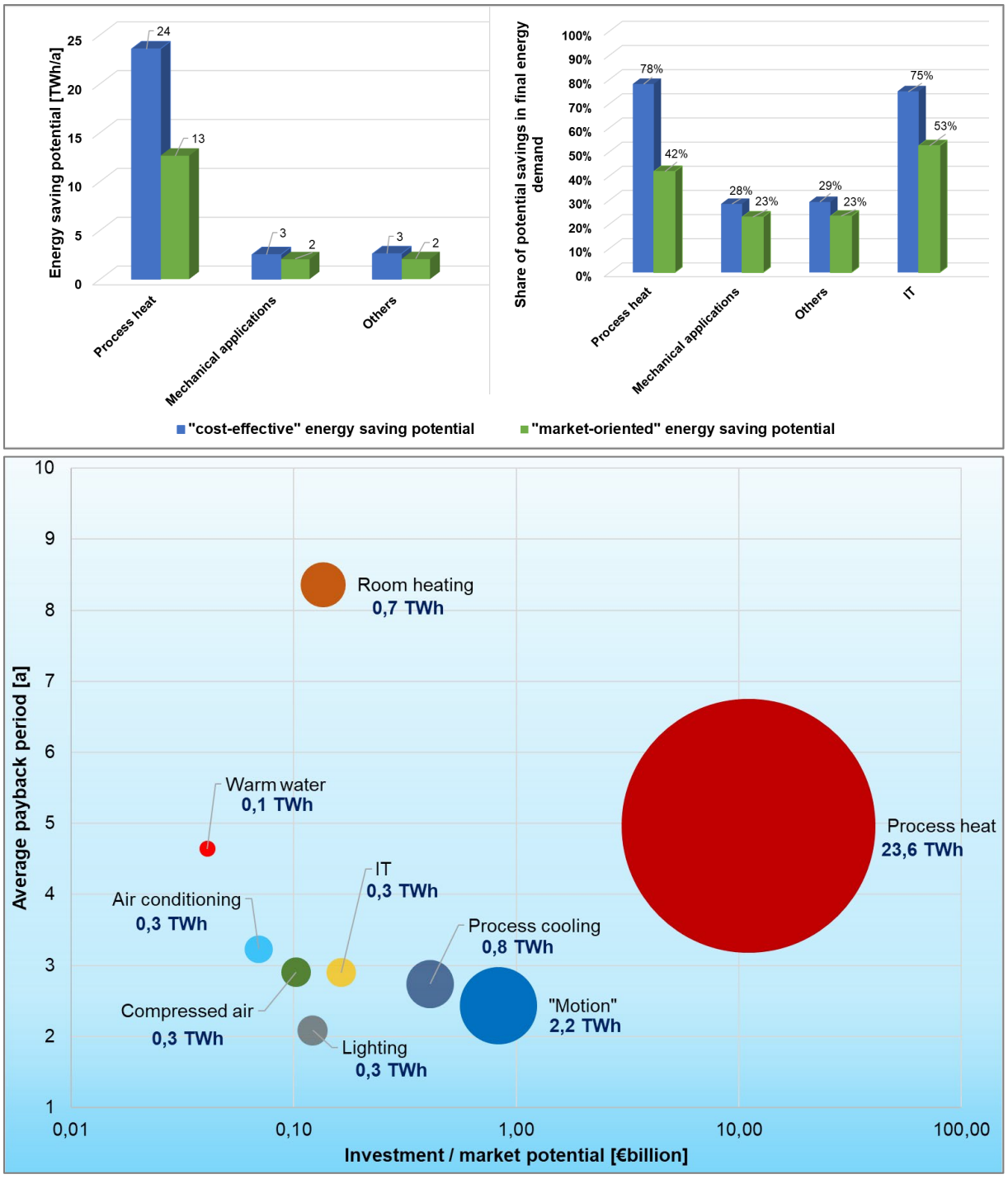

Figure 8: **Results for the food industry[12]: Absolute and relative savings potential per application (top), cost-effective savings potential per application including investments and payback periods (bottom).**

The greatest absolute savings potential continues to lie in the areas of process heat (23.6 TWh/a | 82% – but only up to 500 °C in this case) and "motion" (2.2 TWh/a | 7.5%). However, process cooling is more important in the food industry than in other industries (0.8 TWh/a | 2.9% – see also [17]). A particularly important energy-saving measure in the food industry is the use of heat pumps. This can save around 5.2 TWh/a (around 20% of the total cost-effective energy-saving potential in the food industry). The other significant measures are comparable

to those in other industries: use/avoidance of waste heat (11.5 TWh/a | 40%), improved user behaviour and/or controls (4.3 TWh/a | 15%) and highly efficient motors and speed controls (2.1 TWh/a | 7.4%).

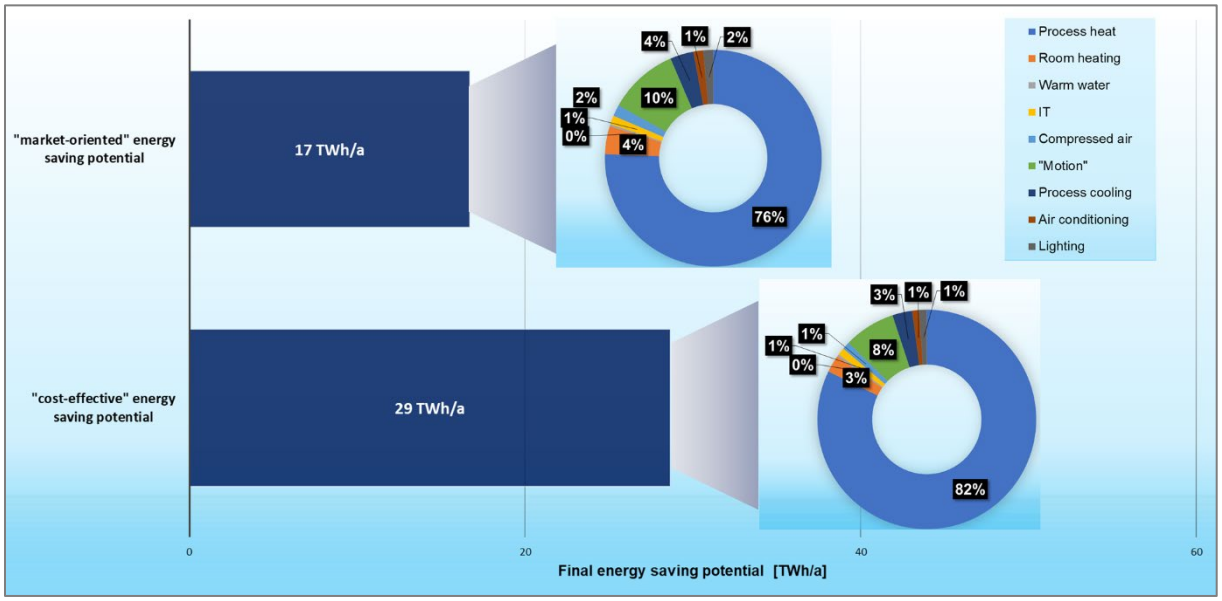

Figure 9: Results for the food industry[12]: Comparison of market-oriented and cost-effective final energy saving potential.

Figure 10 shows a possible investment path. In this scenario, total investments of €13 billion are necessary in the food industry to achieve the cost-effective final energy savings, but these €13 billion are offset by energy cost savings of €32 billion/a in the period 2026–2045.

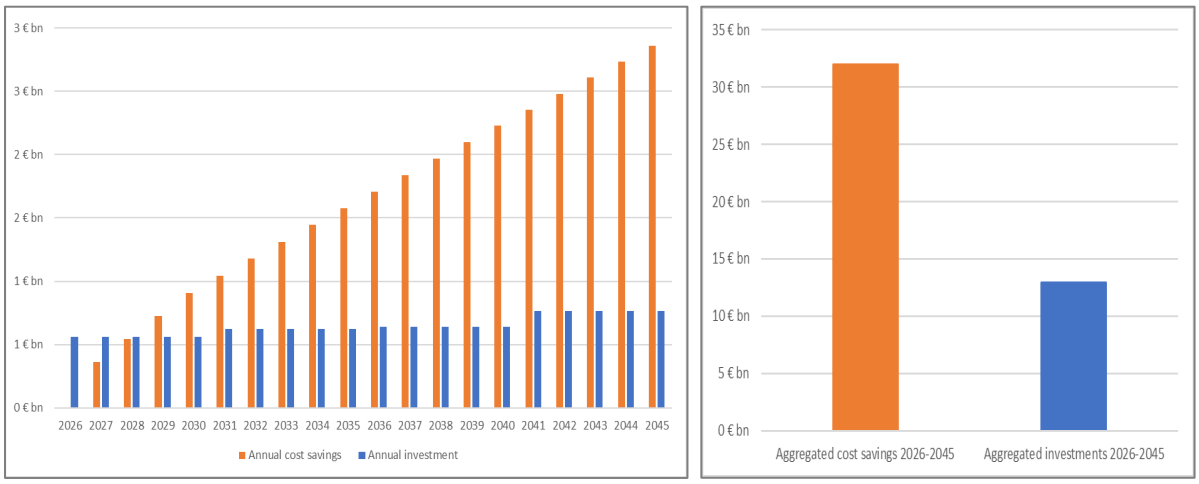

Figure 10: Results for the food industry[12]: Comparison of savings and investments 2026–2045.

Consideration of the “energy-intensive industry”

As the authors do not have access to company-specific data, the definition of "energy-intensive industry" is based on the existing definitions described above. The final energy demand of the following industries (economic sectors in brackets) is summarised here: Food industry ("manufacture of food and animal feed", "beverage production", "tobacco processing"), paper industry ("manufacture of paper, cardboard and goods made from them"), metal industry ("manufacture of metal products", metal production and processing"), chemical industry

("manufacture of chemical products") and glass & ceramics and cement & lime ("manufacture of glass, glassware, ceramics, processing of stone and earth"). Since the "energy-intensive industry" defined here accounts for around 80% of the final energy demand of German industry, it is not surprising that the results are comparable to those for industry as a whole. The greatest absolute savings potential continues to be found in the areas of process heat and "motion". No diagrams are provided.

Economic perspective

The above statements were based on macroeconomic aggregates, as the industry was initially considered as a whole when calculating the potential savings. Subsequently, a selected sector (the food industry) and then energy-intensive sectors were examined in more detail, but here too, the analysis was aggregated. Nevertheless, despite the macroeconomic and sector-specific aggregation, the analysis was based on business management arguments. Individual measures were compared with individual directly attributable benefits: for example, an investment of x € in a heat exchanger can be assigned y €/a in future annual energy cost savings. If a certain number of such measures are implemented in an industry or across the entire country, their aggregate benefit is calculated by multiplying the previously determined individual savings.

However, this approach overlooks some key aspects of energy efficiency measures. In addition to the economic benefits outlined above, there are also broader economic benefits to consider. In fact, many energy efficiency measures have so-called positive external effects[14]: in addition to the benefits accruing to the investors themselves (i.e. those who bear the costs), other companies or even the entire economy also benefit from the measures. However, since individual investors only offset their individual benefits against their individual costs, part of the benefits of a measure (i.e. precisely the part that accrues to others) is not taken into account. This means that, overall, too few measures are implemented in terms of the economic optimum. This argument is not new in the energy industry [27]. In fact, the entire field of environmental and climate protection is based on a similar argument that is already widespread in public debate: here, negative externalities are the cause of market failure, albeit with the opposite sign.[15] Thus, when considering environmental protection measures, a company only considers its own benefits and costs, while the overall economic benefits of reduced environmental pollution are mostly ignored. But there are also popular examples of positive external effects in the energy industry: renewable energies [28]. Here, too, investments have positive effects on the economy as a whole, which are sometimes ignored by individual investors.

Regardless of these theoretical distinctions, however, in all of the examples described above, the current situation is inefficient without some form of government intervention. This means that without government measures, too little is being invested in relation to the optimum – or, conversely, too many pollutants are being emitted or resources used. This misallocation of resources therefore justifies government measures, which usually consist of a mix of

[14] In economics, the concept of external effects is closely associated with Arthur Cecil Pigou (1920). He focused on negative external effects, which form the basis of modern environmental economics. The concept of positive external effects was coined primarily by Henry Sidgwick (1891) and illustrated by the example of the lighthouse. [43]

[15] Market failure refers to various causes that lead to market malfunctions. These require government intervention to enable markets to function efficiently. This must be distinguished from market interventions that take place in already functioning markets. In this case, the efficiency of the market is restricted by government intervention. [44]

"punishment" for negative externalities (or increasing the cost of goods and production methods associated with negative externalities), e.g. in the form of an emissions-based energy tax, and "rewards" positive external effects (or cost reduction for goods or production methods with positive externalities), e.g. in the form of subsidies for photovoltaic systems or electric cars.

When considering benefits that are not included in the economic analysis, several levels of differentiation can be made. The broadest view is taken at the macroeconomic level [29] [30] [31]. This includes numerous positive economic effects of energy efficiency measures, such as:

- Labour market effects: Investments in energy efficiency measures can have positive effects on employment, for example for craftspeople, energy consultants, suppliers or manufacturers of relevant energy efficiency technologies.
- Enhancement of capital stock: More efficient machinery or better insulated buildings represent added value for an economy and, in particular, for future generations.
- Increase in overall economic productivity: This is an important indicator that could potentially be reflected in higher wages, for example.
- Acceleration of technical progress: This is an essential factor for future economic growth rates.

These effects are quite complex to calculate. Quantifying them would go far beyond the technical and economic approach of this brief study. In addition, especially in the case of labour market effects, any declines in employment or capital stock devaluation in other areas (e.g. the fossil fuel industry) must also be taken into account.

A slightly less far-reaching limitation would be to include macroeconomic effects that are predominantly attributable to the energy sector, e.g.:

- Security of supply: Energy efficiency measures reduce the need for imports, especially of fossil fuels. In this way, they contribute to achieving the goals for security of supply as defined in the “Energiewirtschaftsgesetz” (Energy Industry Act) and also divert capital flows to the domestic market.
- Environmental and climate protection goals: The measures also contribute to Germany's fulfilment of its international obligations (e.g. under the Paris Agreement on Climate Change). In addition to achieving "moral" goals, this also avoids concrete penalties for the federal government and thus for taxpayers.

However, most closely related to the business indicators are the economic cost savings within the energy system. Methodologically, these are comparable to operational cost savings or benefit increases, except that they cannot be attributed to a single company individually, but to the overall system (which corresponds to the logic of positive externalities mentioned above). The following are particularly relevant in this context [32] [33] [34]:

- Natural gas power plants: The German government is aiming to build 20 GW of new natural gas power plants [35], [36]. This scale is planned in anticipation of a certain demand. If this turns out to be lower due to additional energy efficiency measures, the functionality of the electricity system can also be ensured with a smaller expansion. However, due to the required flexibility (as is also the case with power lines), a 1:1 effect cannot be assumed, as a certain amount of power must be reserved regardless of consumption.
- Fossil fuel infrastructure: Not least due to the aforementioned decline in new natural gas power plant construction, lower capacities are required in upstream value chains. This

applies to both new facilities (e.g. additional LNG import terminals) and existing infrastructure (e.g. long-distance gas pipelines). In the event of lower natural gas demand (due to lower electricity demand as a result of higher energy efficiency), the latter could be converted to a (green) hydrogen economy earlier and more comprehensively.

- Electricity storage capacities: Lower electricity consumption also means (ceteris paribus) a lower demand for electricity storage facilities. Although a 1:1 translation is not possible here, the effect is clearly positive. It should be emphasised here that the authors are referring to electricity storage facilities to be built from 2040 onwards. In the coming years, the expansion of storage capacities should not be slowed down – rather, it should be intensified.
- Power grid expansion: The argument for electricity storage capacities can also be applied to grid expansion, with a few special considerations. Even if certain transmission lines have to be built regardless of actual demand, lower demand reduces, for example, the safety margins that need to be included and the costs of grid operation (redispatch, balancing energy, etc.). Here, too, it should be emphasised that the expansion of the electricity grids should not be slowed down in the coming years. There are already many bottlenecks that hinder the expansion of renewable energies and electricity storage capacities.

In principle, increasing energy efficiency measures could also lead to a reduction in the expansion of renewable energies instead of reducing the expansion of natural gas power plants. In fact, this would also save the economy corresponding costs. However, in this case, some of the positive external effects mentioned above would be lost.[16] This applies in particular to security of supply (no reduction in import requirements) and the achievement of environmental and climate targets (CO_2 emissions and other pollutants). The savings in LNG terminals and other fossil fuel infrastructure mentioned at the end of the above section are also unlikely to be achievable in such a scenario.

The energy efficiency measures outlined above could significantly reduce the need to expand new natural gas power plants, as end-use energy savings in the electricity sector usually also mean a reduction in peak load. The exact extent of the load reduction depends on the specific characteristics of the energy efficiency measures. In addition to the final energy saved, the temporal distribution of the reduction is also relevant for determining exactly how many fewer power plants need to be built.

The cost of newly built natural gas power plants currently amounts to approximately €1 billion per GW.[17] If only 10 GW were required instead of the 20 GW specified by the German government, the investment requirement would be reduced by €10 billion accordingly. Measured against the investment requirements discussed above, which would result from energy efficiency measures, this sum appears comparatively small at first glance. However, other future costs must also be taken into account in order to make a truly meaningful comparison. The avoided natural gas import costs of the power plants that were not built alone amount to around €1 billion per year [18], meaning that by 2045, twice as much again in avoided

[16] In addition, there is considerable uncertainty regarding the actual future development of electricity demand, meaning that the current reduction in the expansion of renewables may be reversed in the future or raised back to the original level.

[17] Currently published projects range from approximately €450 million to €1.3 billion per GW (with pure gas turbines being cheaper and the more technically efficient combined cycle plants at the upper end of the scale). [45]

[18] This assumes an efficiency of 50%, an average annual full-load operating time of 2,700 hours and an average natural gas price of €33/MWh. These values and the resulting import cost savings are for illustrative purposes

operating costs can be added to the savings in investment. This figure is, of course, heavily influenced by the assumptions made (cross-border price, full-load hours, efficiency, etc.) and may therefore vary upwards or downwards. Based on the assumptions described above, this would represent a total economic benefit of at least €30 billion. For a comprehensive assessment of the savings potential in connection with natural gas power plants, the costs saved from the natural gas network expansion that might otherwise be necessary in some places and the lower costs of the LNG infrastructure would also have to be taken into account. [37]

Obstacles to the implementation of the measures and how to overcome them

The obstacles to implementing measures were discussed in detail in studies, [7], [8], [38] and [39].

Business obstacles

The following table lists the most important obstacles and measures that can be taken to remove or mitigate them.

Obstacle	Measures to remove the obstacle
Lack of motivation	Management commits to an energy management system and thereby motivates employees to reduce energy consumption and energy costs.
Lack of acceptance	By officially appointing energy officers and/or energy teams, management strengthens acceptance of their activities.
Lack of knowledge	Training enables those responsible to identify measures to reduce energy consumption and energy costs. Alternatively, external experts are brought in.
Lack of information	Training courses teach those responsible how to obtain the necessary information.
Lack of personnel	Energy managers and/or energy teams are given the necessary time by management to deal with the issue. Framework agreements are concluded with craft businesses or plant manufacturers.
Relevance of energy costs	The implementation of economically attractive measures shows that money can be saved quickly and easily – even if energy costs are of minor importance.
Claim: investment costs are too high	Many of the measures are "only" behavioural adjustments, organisational optimisation and minor investment measures. High investment costs are not always necessary. And subsidy programmes can also help here.
Liquidity restrictions	It is not always necessary to invest yourself. Numerous equipment manufacturers offer attractive alternative implementation models

only. Depending on the assumptions made, the savings may be significantly lower or higher. For example, [45] shows values between 500 and 6,300 hours for full-load hours in the period under review up to 2045. Border crossing prices for natural gas are also subject to constant fluctuations. Average import prices have ranged between approximately 15 and 75 euro/MWh over the last 10 years. [46]

	(e.g. purchasing compressed air instead of a compressed air compressor, or hot water instead of heating).
Payback period as a calculation method	Economic considerations (discounted cash flow calculation) should always be carried out for all measures. This can clearly highlight the profitability of many energy-saving measures

Economic obstacles

The obstacles listed in the table can be overcome, at least in part, by measures taken within a company. In addition, investments in energy efficiency are hampered by further obstacles that lie outside the sphere of influence of individual companies or even the entire industry. The political regulatory framework is a particularly important factor here. If a country's energy and economic policy is unstable and unreliable, this can lead to massive uncertainty about future developments. This can have a negative impact on investment behaviour, which is explicitly based on expectations for the future. In this case, companies and their industry representatives can only try to raise awareness of the importance of reliability among politicians and engage constructively in legislative processes.

Another obstacle may lie in ownership structures. This is not relevant for most large industrial companies, but for many SMEs, it may well be the case that the buildings are not owned by the company but are only rented. This complicates all such investments (and thus reduces the energy efficiency potential) related to the building (which has long been discussed in the household sector under the heading "landlord-tenant dilemma" [40]). Some investments can be realised through cooperation with the owner, but certainly not all that would be technically and cost-effective.

Subsidies for energy efficiency measures

In classical economic theory, government intervention is initially viewed critically, as it usually restricts the efficiency of functioning markets and is often motivated by distribution policy, as explained above. From the rather theoretical argument outlined above regarding positive external effects in combination with practical obstacles, a fairly clear mandate for the government to intervene in the energy efficiency market can be derived. Thus, the argument that government intervention distorts an efficient market outcome cannot be directly applied to the energy efficiency market, as this market has clearly not yet led to such an efficient market outcome. Unlike in functioning markets, where government intervention leads the market outcome away from the optimum, (well-designed) government intervention in non-functioning markets can lead to a movement towards the optimum.

Following these rather abstract explanations, we will now take a look at the reality of subsidies as presented in the German government's latest subsidy report [41]: The federal government plans to spend €77.8 billion on subsidies in 2026 (target values). The majority of this will be in the form of direct financial assistance (€59.4 billion), with the remainder coming from tax reliefs (€18.4 billion). In both categories, a relatively small number of subsidies account for a large proportion of the total. The top 20 financial assistance programmes (out of a total of 139) account for 91 % of subsidies. In the case of tax reliefs, the 20 highest items (the total number of tax reliefs is not specified) account for 86%.

When looking at subsidies in the energy sector, it is noticeable that they play an enormous role in the list of subsidies. Thirteen of the 20 largest financial subsidies, totalling €42 billion, are in the energy sector (over 70%), while tax reliefs still account for €7.7 billion (over 40%). In terms of financial assistance, it is striking that even within the top 20, a large proportion of subsidies are accounted for by just two schemes (Table 1): subsidies to reduce electricity prices (in accordance with the Erneuerbare-Energien-Gesetz, EEG) and the promotion of energy efficiency and renewable energy measures in the building sector (in accordance with the Guidelines for Federal Funding for Efficient Buildings, BEG). Together, these two schemes account for around half of all federal financial assistance. It should be noted that both types of financial assistance have been declining since 2024 (18.5 and 14.1 billion euros respectively in 2024).

Table 1: The most important energy-specific financial assistance from the federal government [41]

Rank in Top 20	Description of financial assistance	Billion euros (target 2026)
1	Subsidies to offset electricity prices	17.2
2	Promotion of energy efficiency and renewable energy measures in the building sector	12.1
4	Subsidies to electricity-intensive companies to offset electricity price increases due to emissions trading	3.0
6	IPCEI Hydrogen	2.4
8	Grants for the construction of refuelling and charging infrastructure	1.7
9	Transformation of heating networks: Federal funding for efficient heating networks	1.4
10	Federal funding for energy and resource efficiency in industry	1.0
11	Measures for natural climate protection	0.8
13	Decarbonisation of industry/Federal funding for industry and climate protection/Climate protection agreements	0.7
15	Industrial production for mobile and stationary energy storage systems	0.3
16	Promotion of the purchase of buses with alternative drive systems	0.4
18	Subsidies for the purchase of commercial vehicles with alternative, climate-friendly drive systems	0.4
20	Climate-friendly new buildings	0.4

In terms of tax reliefs, there is no clear focus on individual energy-specific subsidies. The highest value in the top 20 is the electricity tax relief for companies (ranked 5th).

Table 2: The most important energy-specific tax reliefs offered by the federal government [41]

Rank in Top 20	Description of tax relief	Billion euros (target 2026)
5	Electricity tax relief for manufacturing companies and companies in the agricultural and forestry sectors (§ 9b StromStG)	2.5
8	Tax relief for electric and externally rechargeable hybrid electric vehicles in company car taxation (§ 6, 8 EnergieStG)	1.7
10	Energy tax relief for electricity generation (§§ 37, 53 EnergieStG)	1.3
11	Tax exemption for electricity from so-called small-scale installations with a nominal electrical output of up to 2 megawatts (§ 9 StromStG)	0.8
13	Electricity tax relief for certain processes and procedures (§9a StromStG)	0.6
19	Tax relief for energy products used in domestic air traffic (§ 27 EnergieStG)	0.4
20	Energy tax relief for certain processes and procedures (§§ 37, 51 EnergieStG)	0.4

A comparison of the two tables reveals that, on the one hand, energy efficiency measures in industry are supported (e.g. items 2, 10 and 13 under financial assistance), but on the other hand, subsidies are also granted for energy consumption (e.g. items 1 and 4 under financial assistance and 5, 13 and 20 under tax reliefs). Even though both types of support benefit companies, they have opposite effects in terms of incentives to invest. An obvious suggestion would be to eliminate the concessions and subsidies for energy consumption and distribute the freed-up funds to energy efficiency promotion measures. This would have the advantage of not requiring any additional federal funds. The two largest items alone (electricity price relief and electricity tax relief for manufacturing industries) would free up €20 billion per year (if completely abolished). However, these two items relate solely to the price of electricity. Abolishing these measures could significantly set back the electrification of industrial processes. It should also be borne in mind that investment measures tend to have a medium to long-term effect, whereas the abolition of tax reliefs would have a very short-term impact. In order not to hamper electrification, the redirection of subsidies could be limited to measures that currently favour the prices of fossil fuels. However, these subsidies, which are not related to the electricity market, are not particularly significant at present: items 19 (energy products for air transport) and 20 (energy tax on certain processes) together amount to only €0.8 billion per year. There are therefore quite narrow limits to a pure reallocation of subsidies in this area.

In the future, there should be an open discussion about whether and how additional government support should and could further promote energy efficiency. In addition to

expanding existing measures, various other instruments with different levels of intervention are possible. Some possible minor interventions would be improved depreciation conditions or further reductions in energy tax rates for the sectors concerned, particularly in the electricity sector, in order to promote electrification. More intensive interventions would include strict requirements for energy efficiency reductions to be implemented, direct government subsidies covering a significant proportion of the investment costs (traditional subsidies in the narrow sense), or even the government covering the entire investment costs.

Before choosing the instruments or mix of instruments, as with any other state intervention, the effects on market outcomes (quantities and prices), the distribution of burdens and benefits, and the state budget must be discussed. Possible legal state aid issues must also be taken into account.

Conclusion

This study on the potential for energy efficiency in industry combines and expands on previous studies from 2023 [7] and 2024 [8] which used similar methods, with updated data and a refined methodology. New features include an industry-specific analysis, a detailed discussion of the economic effects of energy efficiency measures, and the presentation of a possible investment path.

The earlier results are essentially confirmed and show high potential for cost and emission reductions. The energy efficiency potential is slightly lower than previously calculated in some areas. This is partly due to energy efficiency measures implemented in the meantime and partly to declines in production. Changes in payback periods result from the refined methodology, which now uses two payback periods instead of just one, and from changes in energy prices. Since the investment volume and market potential in the study's methodology are calculated from the payback periods, their values are lower in most areas of application.

By implementing cost-effective final energy saving measures (i.e. measures with a positive net present value), 263 TWh/a of final energy demand can be saved in German industry (as of 2023). This represents around 40% of the total final energy consumption of 635.4 TWh/a. Of this, 209 TWh_{th}/a is in the heating sector and 54 TWh_{el}/a is in electricity applications outside the heating sector. A large proportion of the cost-effective final energy saving measures are even "market- oriented measures", i.e. they have payback periods of less than 3 years. The associated savings are around 28% (176 TWh/a), divided into 134 TWh_{th}/a in the heating sector and 42 TWh_{el}/a for electricity applications outside the heating sector.

Typical energy-saving measures include improved user behaviour, optimised control through automation (including AI approaches), operating and maintenance measures, insulation of pipes, fittings, machines and buildings, waste heat utilisation, speed-controlled drives, the use of highly efficient motors and the use of free cooling. The renewal of equipment (use of energy-efficient, demand-adapted new equipment such as machines, devices, lighting) was also taken into account, as was the use of environmental heat. The switch to heat pumps is an important measure, particularly in the heating sector up to 200 °C. The total savings achieved through the electrification of processes in heating applications account for around 20%.

Based on the energy price developments assumed in the study, the cost-effective final energy savings in 2025 correspond to a cost saving of around €29 billion per annum. The necessary investment is estimated at a total of €104 billion, resulting in an average payback period of 3.6 years. Cumulatively over the next 20 years, the total savings for the investment path described in the study amount to around €250 billion, more than double the investment sum.

An industry-specific analysis of the food industry shows that it has a disproportionately high potential of 11% of the total industry's possible energy savings, even though the sector accounts for only 7% of final energy consumption. An important reason for this is the high proportion of heat applications in the low-temperature range, where heat pumps can be used effectively. Focusing on energy-intensive industries yields results that are largely unchanged compared to industry as a whole, as this sector accounts for 80% of consumption and thus also the largest share of efficiency potential.

Economic benefits include lower investment requirements in energy infrastructure (especially controllable backup capacities such as natural gas power plants) and reduced dependence on imports (especially natural gas). This is because energy efficiency measures not only reduce demand but also peak loads. If 10 GW fewer gas-fired power plants need to be built by 2045, the investment requirement would be reduced by around €10 billion. In addition, there would be avoided natural gas import costs of around €1 billion per year for the power plants that were not built, resulting in a cumulative economic benefit of €30 billion over 20 years for gas-fired power plants alone.

Also worth mentioning in terms of economic impact are the contribution to security of supply (reduction in the need to import fossil fuels), support for the achievement of international commitments (e.g. Paris Agreement) and thus, where applicable, the avoidance of specific penalties, positive employment effects (e.g. for craftspeople, energy consultants, suppliers or manufacturers of relevant energy efficiency technologies), the appreciation of capital stock (more efficient machines or better insulated buildings represent added value for an economy), an increase in overall economic productivity (e.g. higher wages in the future) and the acceleration of technical progress.

Despite its high potential, energy efficiency is often given little attention in discussions about a cost-effective energy transition. Obstacles to the implementation of energy efficiency measures in businesses include liquidity constraints, a lack of personnel capacity (skills shortage) and the desire for short payback periods.

Furthermore, investments in energy efficiency are hampered by additional obstacles that lie outside the sphere of influence of individual companies or even the entire industry. The political regulatory framework is a particularly important factor here. Ownership structures can also be another obstacle. If the buildings are not owned by the company but are only rented, this makes it more difficult to make any investments related to the building.

Regardless of whether such measures are politically promoted, their benefits for companies are considerable. In addition, they support the speed of the energy transition away from fossil fuels and towards electricity.

Bibliography

[1] Agora Energiewende, „Erneuerbare Energien senken Strompreise unabhängig von der Nachfrage," 2025.

[2] Stiftung Klimaneutralität, „Einordnung des Energiewende-Monitoring – Acht strategische Dimensionen zur Zukunft Deutschlands, Seite 11ff.,," Berlin, 2025.

[3] Vereinigung der Bayerischen Wirtschaft e. V. (vdw), „Prognos Strompreisprognose," 2023. [Online]. Available: Zugriff: 18.03.2024. Unter: https://www.vbw-bayern.de/Redaktion/Frei-zugaengliche-Medien/Abteilungen-GS/Wirtschaftspolitik/2023/Downloads/vbw_Strompreisprognose_Juli-2023-3.pdf.

[4] European Commission, „Action Plan for Affordable Energy - Unlocking the true value of our Energy Union to secure affordable, efficient and clean energy for all Europeans, COM(2025) 79 final," Brussels, 2025.

[5] AG Energiebilanzen e.V., „Energieverbrauch in Deutschland im Jahr 2024," 2025.

[6] Umweltbundesamt, „Energieverbrauch und Energieeffizienz in Deutschland in Zahlen," Umweltbundesamt, Themen, Klima | Energie, Energiesparen, 04. 08. 2025. [Online]. Available: https://www.umweltbundesamt.de/themen/klima-energie/energiesparen/energieverbrauch-energieeffizienz-in-deutschland-in#Klimaschutz. [Zugriff am 18. 09. 2025].

[7] J. Meyer, M. Madsen und L. Saars, „Kurzstudie Energieeffizienzmaßnahmen in der Industrie - Marktnahe und wirtschaftliche Energieeinsparpotentialein der Industrie," 2023.

[8] J. Meyer, L. Zaubitzer, F. Alsmeyer und M. Madsen, „Kurzstudie: Energieeffiziente und CO_2-freie Prozesswärme," 2024.

[9] Bundesregierung, *Energiefinanzierungsgesetz.*

[10] European Commission, *EU-Energiesteuerrichtlinie 2003/96/EG,* 2003.

[11] Statistisches Bundesamt (Destatis), *Branchen-Unternehmen: Industrie-Verarbeitendes-Gewerbe: Produktionsindex-energieintensive-Branchen.*

[12] Informationsdienst des Instituts der deutschen Wirtschaft (iwd), „Energieintensive Industrien wichtig für deutsche Wirtschaft," 2023.

[13] Frauenhofer ISI, „Erstellung von Anwendungsbilanzen für die Jahre 2021 bis 2023 für die Sektoren Industrie und GHD," Studie für die Arbeitsgemeinschaft Energiebilanzen e.V. (AGEB), [Online] Available: https://ag-energiebilanzen.de/wp-content/uploads/2024/11/Anwendungsbilanz_Industrie_2023_final_20250324.pdf [Zugriff am 22.09.2025], 2025.

[14] Bundesministerium für Wirtschaft und Energie (BMWi), ENERGIEEFFIZIENZSTRATEGIE 2050, Berlin, 2019.

[15] Agora Industrie und FutureCamp, „Power-2-Heat: Erdgaseinsparung und Klimaschutz in der Industrie," 2022.

[16] D. Schüwer, „Transformation in der Industrie: Herausforderungen und Lösungen für erneuerbare Prozesswärme," 2023.

[17] J. Meyer, S. Möhren und L. Saars, „Klimaneutrale und wettbewerbsfähige Ernährungsindustrie bis 2030, Leitfaden zur Dekarbonisierung der Prozesswärmebereitstellung," Verband Deutscher Wirtschaftsingenieure e.V. (VWI), 2022.

[18] J. Burchardt, K. Franke, P. Herhold, M. Hohaus, H. Humpert, J. Päivärinta, E. Richenhagen, D. Ritter, S. Schönberger, J. Schröder, S. Strobl, C. Tries und A. Rürpitz, „KLIMAPFADE 2.0 - Ein Wirtschaftsprogramm für Klima und Zukunft," Boston Consulting Group , 2021.

[19] C. Jugel, et. al., „dena-Leitstudie Aufbruch Klimaneutralität," Deutsche Energie-Agentur GmbH (dena), Berlin, 2021.

[20] C. Maaß, M. Sandrock und G. Fuß, „Kurzgutachten - Strategische Optionen zur Dekarbonisierung und effizienteren Nutzung der Prozesswärme und -kälte," Hamburg Institut, 2018.

[21] Fraunhofer ISI Institut für Industrieofenbau und Wärmetechnik (IOB) der RWTH Aachen University, „CO_2-neutrale Prozesswärmeerzeugung," Umweltbundesamt, 2023.

[22] G. Luderer, C. Kost und D. Sörgel, „Deutschland auf dem Weg zur Klimaneutralität 2045," Institute for Climate Impact Research, Potsdam, 2022.

[23] Prognos AG; Öko-Institut e. V. und Wuppertal Institut für Klima, Umwelt, Energie gGmbH, „Klimaneutrales Deutschland 2045," Agora Energiewende, 2021.

[24] Prognos AG, Fraunhofer ISI und Technische Universität München, „Datenbasis zur Bewertung von Energieeffizienzmaßnahmen in der Zeitreihe 2005 – 2014 - Endbericht," Umweltbundesamt, 2016.

[25] Statistisches Bundesamt (Destatis), Genesis-Online, „Energieverbrauch der Betriebe im Verarbeitenden Gewerbe: Deutschland, Jahre, Nutzung des Energieverbrauchs, Wirtschaftszweige, Energieträger," Destatis, Wiesbaden, 2025.

[26] Bundestelle für Energieeffizienz, „Plattform für Abwärme," [Online]. Available: https://www.bfee-online.de/BfEE/DE/Effizienzpolitik/Plattform_fuer_Abwaerme/plattform_fuer_abwaerme_node.html. [Zugriff am 18 09 2025].

[27] B. K. Sovacool, J. Kim und M. Yang, „The hidden costs of energy and mobility: A global meta-analysis and research synthesis of electricity and transport externalities.," *Energy Research & Social Science,* Bd. 72, 2021.

[28] A. Seeliger, Volkswirtschaftliche Grundlagen zu Wirtschaftlichkeit, Versorgungssicherheit und Umweltverträglichkeit. 2. Auflage., München: Vahlen, 2022.

[29] DENA; Prognos AG; Ecofys und PwC, „Gesamtwirtschaftliche Einordnung der ESG - BMWi-Projekt-Nr.: 102/16-01-1," 2017. [Online]. Available: https://www.prognos.com/sites/default/files/2021-03/gesamtwirtschaftliche_einordnung_der_esg_final.pdf. [Zugriff am 19. 9. 2025].

[30] Gesellschaft für wirtschaftliche Strukturforschung (GWS); Fraunhofer ISI; Deutsches Institut für Wirtschaftsforschung (DIW); Deutsches Zentrum für Luft- und Raumfahrt (DLR) und Prognos AG, „Gesamtwirtschaftliche Effekte der Energiewende. GWS Research Report 2018/04," 2018. [Online]. Available: https://www.gws-os.com/de/energie-klima/projekte/detail/bmwi-makro-ew. [Zugriff am 19. 9. 2025].

[31] International Energy Agency (IEA), „Multiple Benefits of Energy Efficiency," 2025. [Online]. Available: https://www.iea.org/reports/multiple-benefits-of-energy-efficiency. [Zugriff am 19. 9. 2025].

[32] Boston Consulting Group (BCG); Institut der deutschen Wirtschaft (IW) und Bundesverband der Deutschen Industrie (BDI), „Energiewende auf Kurs bringen," 2025. [Online]. Available: https://energiewende.bcg.com/home/. [Zugriff am 19. 9. 2025].

[33] McKinsey, „Zukunftspfad Stromnachfrage," 2025. [Online]. Available: https://www.mckinsey.de/news/presse/2025-01-20-zukunftspfad-stromnachfrage. [Zugriff am 19. 9. 2025].

[34] Prognos AG und Institut für Elektrische Anlagen und Netze, Digitalisierung und Energiewirtschaft (IAEW) der RWTH Aachen, „Positive Effekte von Energieeffizienz auf den deutschen Stromsektor," Agora Energiewende, [Online] Available: https://www.agora-energiewende.de/fileadmin/Projekte/2012/positive-effekte-energieeffizienz/Agora_ECF_RAP_Effizienzstudie_DE_web.pdf [Zugriff am 19.09.2025], 2014.

[35] Bundesnetzagentur, „Stand und Entwicklung der Versorgungssicherheit im Bereich der Versorgung mit Elektrizität," Bonn, 2025.

[36] Frontier Economics, „KRAFTWERKSSTRATEGIE: FESTLEGUNG AUF GAS ODER TECHNOLOGIEMIX? - Kurzstudie im Auftrag des Landesverband Erneuerbare Energien NRW e.V.," 2025.

[37] Bundesnetzagentur, „Genehmigung des Szenariorahmens für den Netzentwicklungsplan Gas und Wasserstoff," [Online] Available https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/NEP/Gas/start.html [Zugriff am 19.09.2025], 2025.

[38] K. Barzantny, M. Haverkamp, E. König, J. Meyer, U. Niehage, V. Orioli und A. Trautmann, „Energieeffizienzpotentiale und Umsetzungshemmnisse in der Industrie," *Energiewirtschaftliche Tagesfragen,* pp. 16-20, 11. 2013.

[39] J. Meyer, A. Domning, M. Freiberg, U. Maurer, P. Mier, C. Schmidt, B. Strotmann und A. Wiesgen-Pick, Steigerung der Energieeffizienz bei der Spirituosenherstellung. Anleitung mit Best-Practice-Beispielen, Bonn: Bundesverband der Deutschen Spirituosen-Industrie und -Importeure e. V. (BSI), 2024.

[40] R. Henger, S. Braungardt, J. Karras, B. Köhler und G. Reeh, „Schweden als Vorbild zur Überwindung des Vermieter-Mieter-Dilemmas – (Teil-)warmmieten oder Reform der Modernisierungsumlage?," Kopernikus-Projekt Ariadne, Potsdam, 2023.

[41] Bundesministerium der Finanzen, „30. Subventionsbericht des Bundes 2023-2026," [Online] Available: https://www.bundesfinanzministerium.de/Content/DE/Pressemitteilungen/Finanzpolitik/2025/09/2025-09-10-30-subventionsbericht.html [Zugriff am 21.09.2025], 2025.

[42] 17463:2021-12, VALERI-Norm DIN EN, „Bewertung von energiebezogenen Investitionen (Valuation of Energy Related Investments)," 2021.

[43] M. Schröter, M. Groth und S. Baumgärtner, „Pigous Beitrag zur Nachhaltigkeitsökonomie," *University of Lüneburg Working Paper Series in Economics,* Nr. 180, 2010.

[44] M. Fritsch, Marktversagen und Wirtschaftspolitik – Mikroökonomische Grundlagen staatlichen Handelns. 10. Auflage., München: Vahlen, 2018.

[45] Fraunhofer ISE, „Studie: Stromgestehungskosten Erneuerbare Energien," [Online] Available: https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/studie-stromgestehungskosten-erneuerbare-energien.html [Zugriff am 19.09.2025], 2024.

[46] Energy Institute, „Statistical Review of World Energy. 74. Auflage.," [Online] Available: https://www.energyinst.org/statistical-review [Zugriff am 19.09.2025], 2025.

[47] Statistisches Bundesamt (Destatis), „Volkswirtschaftliche Gesamtrechnung – Arbeitsunterlagen Investitionen," 4. Vierteljahr 2024. [Online]. Available: https://www.destatis.de/DE/Themen/Wirtschaft/Volkswirtschaftliche-Gesamtrechnungen-Inlandsprodukt/Publikationen/Downloads-Inlandsprodukt/investitionen-xlsx-5811108.html. [Zugriff am 21. 9. 2025].

[48] Fraunhofer ISI, Evaluation Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft (Zuschuss und Kredit/Förderwettbewerb), Karlsruhe, Basel, Stuttgart, Berlin: Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA), 2023.

[49] Statistisches Bundesamt (Destatis), Genesis-Online, „Energieverwendung der Betriebe im Verarb. Gewerbe - Stromerzeugung, Strombezug, Stromabgabe, Stromverbrauch," Destatis, Wiesbaden, 2025.

[50] Statistisches Bundesamt (Destatis), Genesis-Online, „Code: VBR001, Erläuterungen: Energieverbrauch,“ 2019. [Online]. Available: https://www-genesis.destatis.de/datenbank/online/statistic/85121/table/85121-0001#modal=table-term-info&params=JTVCJTdCJTIycGFyYW1zJTIyJTNBJTdCJTIybGlua0lkJTIyJTNBJTIyQ19WQlIwMDElMjIlN0QlN0QlNUQ=. [Zugriff am 22. 09. 2025].

[51] AG Energiebilanzen e.V., „Auswertungstabellen zur Energiebilanz Deutschland, Daten für die Jahre von 1990 bis 2024,“ Juni 2025. [Online]. Available: https://ag-energiebilanzen.de/wp-content/uploads/EBD24p1_Auswertungstabellen_deutsch.pdf. [Zugriff am 22. 09. 2025].

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