ENERGY EVALUATION EUROPE
25 SEP - 26 SEP 2025
frizzforum BERLIN
ENERGY EVALUATION EUROPE CONFERENCE 2025
Show me the Evidence: Evaluation as the Decision Maker's Best Resource
www.energy-evaluation.org
Organised by

Results and recommendations from a five-year evaluation of Germany's flagship programme for energy and resource efficiency in industry

Lisa Neusel & Simon Hirzel
Fraunhofer Institute for Systems and Innovation Research ISI
Breslauer Strasse 48, 76139 Karlsruhe, Germany
Email: lisa.neusel@isi.fraunhofer.de, simon.hirzel@isi.fraunhofer.de
ORCID Lisa Neusel: 0009-0009-5537-1224
ORCID Simon Hirzel: 0000-0002-6323-917X

Note: This file is an intermediate version of the paper submitted to the special issue "Show Me the Evidence: Evaluation as the Decision Maker's Best Resource" of the Energy Efficiency journal. Final versions of the papers will be available at this link: https://link.springer.com/collections/gghbiedaaj

ABSTRACT

The 'Federal Funding Scheme for Energy and Resource Efficiency in the Economy' (EEE) is a key programme supporting German companies in their transition to climate neutrality. The multi-measure programme funds various technologies through different funding modules, including technology-open funding. This paper presents results from five evaluation rounds (2019-2023) for the first time, extending the empirical basis on funding scheme evaluations for industrial energy efficiency. The methodological framework consists of quantitative and qualitative key performance indicators (KPIs) categorized by core evaluation areas. Particular attention is paid to the results on greenhouse gas savings and funding efficiency. As a second focus, recommendations from the evaluation for future energy and resource efficiency programmes are outlined.

The KPI analysis reveals no substantial need for structural revisions: With 2.9 billion euros in funding, the EEE supported 9.7 billion euros in investments from 2019 to 2023. It achieved calculated annual gross GHG savings of nearly 7 million tonnes of CO2-eq. The evaluation also offers key insights: Establishing a streamlined target system with realistic objectives is important to avoid trade-offs between multiple aims. A stable funding environment, short processing times and clear guidelines support accessibility. Considering evaluation requirements during programme design can enhance data quality for ex-post analyses. Reaching underrepresented groups can be enhanced by engaging multipliers, using new communication channels, and offering targeted support for SMEs. Finally, the evaluation shows that while a technology-open funding approach supports significant savings, technology-focused funding promotes broader engagement and future funding opportunities, underscoring the validity of both approaches in the funding landscape.

Keywords

energy efficiency, resource efficiency, decarbonization of industry, funding, energy policy, climate change, evaluation

Introduction

Publicly funded policy measures are an important cornerstone to improve energy efficiency (e.g. Patel et al., 2021). Since they are financed by public resources, evaluations are commonly required. When evaluations are conducted, their results are often published only in grey literature. As a result, they are not accessible to the wider academic and policy community. A programme evaluation is defined as a "systematic assessment of the operation and/or the outcomes of a program or policy, compared to a set of explicit standards, as a means of contributing to the improvement of the program or policy" (Weiss, 1998, 4). So called summative evaluations are conducted ex-post, i.e. at the end of a policy implementation, with a focus on measuring and documenting quality indicators for decision-making. The results of the evaluation can be used to improve the performance of future policies (Parsons, 2003). They may thus help to include insights for estimating the costs and implications of future measures in ex-ante assessments (Brunzema et al., 2022), but also to compare the performance of different measures (e.g., Andrei et al., 2021), or tailoring these measures to various locations and conditions (e.g., Tanaka, 2011). Yet Tanaka (2011) surveyed more than 300 energy efficiency policies in the industry sector, encompassing about 570 measures, implemented by governments in IEA countries. They found, among others, that there are too few evaluations of policy measures to understand how they could for example be transferred to other settings. In view of a substantial number of industrial energy efficiency policies in place (e.g. Herce et al., 2024; Safarzadeh et al., 2020), comparatively few evaluations seem to be published in academic journals. Reasons may include that evaluation reports tend to remain within the domain of grey literature and in local languages for their responsible institutions, mainly to validate the success of a programme.

Despite increasing reporting requirements on public energy efficiency programmes in Europe over recent years, scientific publications on summative evaluations in the industrial context seem to remain rare. Harmelink et al. (2008), for example, conclude for Europe that despite an increasing number of energy efficiency policy instruments there and elsewhere, only few of these instruments have systematically been evaluated. In their analysis of 20 ex-post evaluations of energy efficiency policy instruments applied across different sectors - not limited to industry - and different countries in Europe, they note that monitoring information is often not collected on a regular basis. Similarly, Fleiter et al. (2012) note that only a few energy efficiency policies in Europe have been thoroughly evaluated.

To contribute to extending the empirical basis on evaluations of programmes for industrial companies in scientific literature, this paper presents the quantitative evolution of an ex-post evaluation of the German 'Federal Funding Scheme for Energy and Resource Efficiency in the Economy' (EEE) over a five-year period. The EEE was introduced in 2019 as a successor to the German Energy Efficiency Fund (Voswinkel, 2018). Initially mainly focusing on energy efficiency in companies, resource efficiency measures have also been eligible for funding since the end of 2021. With the aim of extending the empirical basis on evaluations of public funding schemes, the paper focuses on the following research questions:

- What do the key performance indicators (KPIs) of the five-year evaluation from 2019 to 2023 reveal regarding the overall impact of the EEE and its individual modules?
- What can we learn from the evaluation results for future energy and resource efficiency programmes?

The paper is structured as follows: A brief overview of the EEE is followed by a review of evaluations of other industrial energy and resource efficiency programmes and a comparison of the EEE's key features compared to measures in other European countries. This is followed by an introduction to the evaluation methodology and a presentation of the results from five years of evaluation. Thereafter, recommendations from the evaluation for future energy and resource efficiency programmes are outlined and final conclusions are provided.

The evaluation of the EEE and related literature

Overview of the EEE

Reporting on policy measures for meeting energy efficiency and climate objectives has considerably progressed in recent years on the European level, but also offers potentials for further improvements (Economidou et al., 2022). The European Union has detailed requirements pertaining to the communication of measures for the implementation of Article 8 on energy savings obligations of the revised Energy Efficiency Directive (Directive 2023/1791/EU, Annex V). Also on national levels, more stringent requirements have been emerging. Germany's objectives regarding energy and climate, for example, include the overarching aim of achieving greenhouse gas neutrality by 2045. These are established by law in the amended Federal Climate Change Act of 2021 and the Energy Efficiency Act of 2023. Both acts include various national reporting obligations that entail the evaluation of implemented measures.

In Germany, the EEE is a federal flagship programme for funding energy and resource efficiency, which needs to be regularly evaluated within the national reporting requirements. There are other programmes not solely directed towards energy efficiency, but which might also trigger industrial energy efficiency, such as Germany's BIK or the European Innovation fund.

The EEE is a multi-measure scheme which aims at promoting energy- and resource-efficient technologies and processes available on the market. The EEE came into force in 2019 as a successor to the German Energy Efficiency Fund (Voswinkel, 2018). Since its introduction, several changes have been made to the underlying legal basis, the funding directive, including minor and major amendments (Neusel, Hirzel, Weinert, et al., 2024). Companies of all sectors and sizes, municipal utilities and energy service providers intending to invest in efficient and sustainable technologies and processes can request public investment support with the EEE. In its current form, the multi-measure scheme is divided into six modules and offers grant-based, credit-based and competition-based subsidies (Figure 1). In its original setup at its initiation in 2019, it covered support for investments in four modules: 1) energy-efficient cross-cutting technologies, 2) process heat from renewable energies, 3) measurement and control equipment, sensors and energy management software and 4) energy optimizations of plants and processes. In 2021, the last module was extended to also cover resource efficiency. Furthermore, two new modules have been added in 2021 and 2023, focusing on 5) transformation plans and 6) electrification in micro and small enterprises.

The flexible design of the programme allows funding of many technologies. Several modules offer funding for technology-focused individual measures (Module 1 to 3 and 6), while another part of the programme funds technology-open systemic measures (Module 4 and the funding competition). For the latter, eligible investments are defined by funding topics rather than by specific technologies. In the competitive line, market-based elements are introduced. Here, submissions are ranked according to their funding efficiency and only the most competitive offers obtain funding in the form of a grant. The competitive line of the EEE has its roots in the former energy efficiency auction program "Step up!" which was in force in Germany from 2016 and 2019 and had a similar funding competition process (Heinrich et al., 2019). Comparable energy efficiency auctions have also been established in Switzerland (“ProKilowatt”; Radgen et al., 2016) and more recently in Denmark (Energistyrelsen, 2022). Funding for conceptual measures (Module 5) complements the funding options. Here, companies obtain funding for drawing up a transformation plan within 12 months that provides a long-term reduction pathway for CO_2 emissions of at least 40 per cent in the areas of Scope 1 and Scope 2 emissions within the next 10 years. The plan must contain realistic and implementable measures for decarbonisation.

According to the latest amendment of the EEE relevant for this evaluation[1], it aims at facilitating the implementation of energy and resource efficiency measures in companies, thereby targeting savings of 35 TWh of final energy and 19 million tons of carbon dioxide emissions from 2022 until the end of 2028 (Richtlinie

[1] Note that beyond the years 2019 to 2023 evaluated in this contribution, the funding directive was updated.

Förderwettbewerb, 2024/25.01.2024; Richtlinie Zuschuss und Kredit, 2024/25.01.2024). In 2023, the EEE's subsidies exceeded 1 billion Euros for the first time.

In Germany, there is a requirement to thoroughly evaluate all energy efficiency policies financed by federal budgets in the Federal Budget Code (Bundeshaushaltsordnung – BHO). According to its Article 7, measurable BHO goals and indicators are to be mapped as an approach for the cost-effectiveness analysis of funding programmes to make the degree of target achievement measurable. The successful evaluation of financial measures generally consists of three monitoring steps: (1) target achievement (2) effectiveness and (3) efficiency.

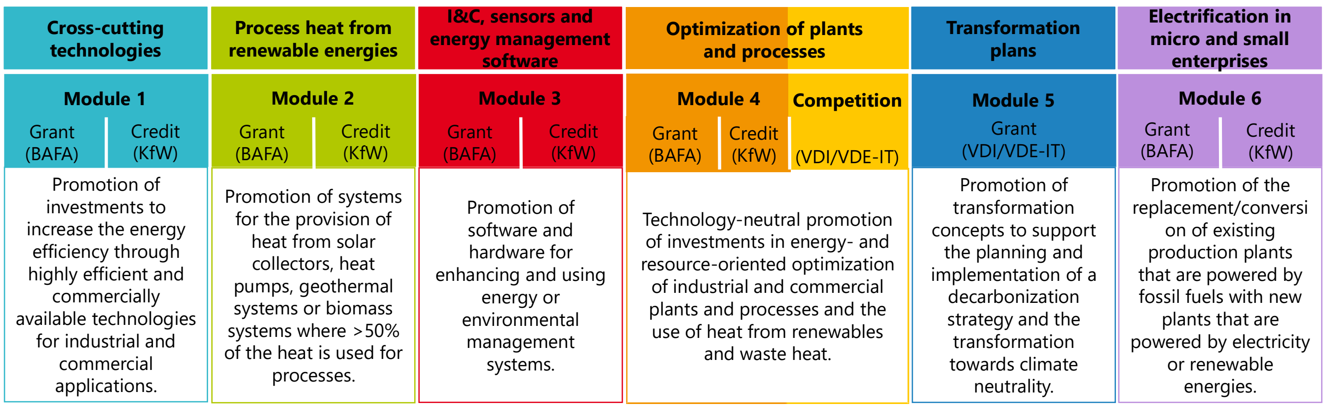

Figure 1. Overview of the six EEE funding modules (*Source*: Neusel, Hirzel, Heinrich, et al., 2024).

Evaluation of Industrial Energy and Resource Efficiency Programmes

The literature on evaluating industrial energy efficiency programmes highlights two needs. First, evaluation methods should be improved and better harmonized. Second, the empirical basis of evaluations should be broadened. Suggested improvements include analysing the entire policy implementation process, not just the final impacts (Harmelink et al., 2008). Other suggestions are to consider transaction costs in financial support programmes (Valentová et al., 2018) or to extend the discussion about cost-effectiveness in evaluations to multiple stakeholders (Yushchenko & Patel, 2017). Next to methodological extensions, there is also a need to further harmonizing evaluations: Comparisons of several methods for tracking industrial energy efficiency on national level, for example, suggest that there is a need to carefully compare results among countries due to different methodological choices (Abeelen et al., 2019). This observation is also applicable to individual programmes as observed for energy audit programmes (Andersson et al., 2017). To overcome such differences, guidance on the policy design phase for measures addressing industrial SMEs has been suggested (Johansson et al., 2019) and harmonizing guidelines for ex-ante evaluations of industrial energy efficiency policies has been suggested (Andrei et al., 2021).

Besides methodological aspects, various authors stress the need for further empirical evaluation studies. Tanaka (2008) underlines the large variety of needs that policy measures need to address and points to an insufficient number of ex-post evaluations to provide learnings for different locations and contexts. Likewise, Herce et al. (2024) underline a lack of analyses on quantitative impacts of energy efficiency policies as a requirement for policies for SMEs. While there are evaluations relating to industrial energy efficiency based on mandatory requirements (e.g. Locmelis et al., 2020) or voluntary agreements (e.g. Stenqvist & Nilsson, 2012), Table 1 seeks to provide an overview of ex-post evaluations from academic literature that include quantitative data on financial support programmes such as the EEE. The focus on financial programmes has been chosen since these programmes typically have special requirements and KPIs within their evaluation. This is owed to the fact that they distribute public money. They thus tend towards substantially higher financial budgets than information measures or measures for ensuring compliance. Thus, requirements to an efficient and effective use of funding are stricter and more KPIs address cost-effectiveness.

Table 1. Quantitative ex-post evaluations of financial support programmes for companies.

Publication	Programme	Country
Anderson and Newell (2004)	US Department of Energy's Industrial Assessment Centers (IAC)	United States of America
Andersson et al. (2018)	Swedish Energy Audit Programme	Sweden
Backlund and Thollander (2015)	Swedish Energy Audit Programme	Sweden
Fleiter et al. (2012)	German Energy Audit Programme for Firms	Germany
Harris et al. (2000)	Commonwealth Government's Enterprise Energy Audit Programme	Australia
Hirzel and Schlomann (2022)	German Energy Efficiency Fund	Germany
Johansson et al. (2022)	Swedish Regional Energy Efficiency Network Programme	Sweden
Mills (1991)	Several Support Schemes for Lighting	Several
Paramonova and Thollander (2016)	Swedish Energy Audit Programme	Sweden
Thollander et al. (2007)	Project Highland	Sweden
Thollander and Dotzauer (2010)	National industrial energy program towards industrial SMEs	Sweden

The majority of existing quantitative studies relating to financial support programmes concern evaluations of audit programmes, e.g. Anderson and Newell (2004), Thollander et al. (2007) or Fleiter et al. (2012). The focus on energy audit programmes is also mirrored by Johansson et al. (2019) who underline that many scientific contributions relate to energy audit programmes for industrial SMEs. Similarly, in the study by Herce et al. (2024), the authors were only able to extrapolate quantitative results for 14 programmes from 10 countries, all related to energy audits. Available analyses, such as in Fleiter et al. (2012) for example, present an ex-post evaluation of the German energy audit programme. The authors evaluate the programme's impact in terms of energy savings, CO_2 mitigation, and cost-effectiveness for the years 2008 to 2010 and compare their results with similar programs from Sweden, the United States of America and Australia. Yet, there generally seems to be a concentration of academically published evaluation reports on industrial energy efficiency funding for few countries only, specifically Germany and Sweden. Among them is an in-depth evaluation study from Germany which is closely related to the EEE. It is on the Energy Efficiency Fund, i.e. the predecessor of the EEE (Hirzel & Schlomann, 2022). The Fund is similar to the EEE since it is a programme with multiple measures and target groups. Between 2011 and 2019, it was the largest cross-sectoral source of financing for energy efficiency improvements in Germany, including more than 20 national policies across all sectors including funding programmes for companies (SMEs and non-SMEs). The analysis assesses the overall impact of the Fund between 2011 and 2019 and points out aggregation problems in such multi-measure schemes.

Another aspect particularly relevant to the evaluation of the EEE is the promotion of resource efficiency improvements. While available scientific literature is mainly energy-related, it has been observed that resource efficiency can make substantial contribution, especially for greenhouse gas (GHG) reductions (Weinert et al., 2024). In the EEE, funding for resource efficiency projects was introduced for the first time in November 2021. An overview of the funding activities in the first year after its introduction is covered by Weinert et al. (2024). They show that material substitution measures funded within the EEE, particularly in the cement, metal and plastics industries, are characterised by high absolute greenhouse gas reductions. According to Wilts and O'Brien (2019), the formulation of resource efficiency policies is still in its early stages in many EU member states, characterised by fragmented instruments and overlapping competencies (Domenech & Bahn-Walkowiak, 2019), with some notable exceptions (Bahn-Walkowiak & Wilts, 2017). To the authors' knowledge, none of the existing evaluation studies on industrial energy efficiency programmes so far cover resource efficiency.

Key features of the EEE compared to measures in other EU countries

According to the 2024 EU Energy Efficiency Scoreboard among all EU countries (ODYSSEE-MURE, 2024), Germany ranks third behind Poland and Finland in terms of energy efficiency policies in industry. The energy savings achieved by energy efficiency policy measures are a major factor in Germany's high position in the industry ranking. The EEE achieves by far the highest energy savings, both in Germany and in all other EU countries (Table 2).

Table 2. Measures to promote energy efficiency in industry with the highest final energy savings in EU countries

Country	**Measures**	**Type**	**Final energy saving by 2030 in PJ**
Germany	Federal funding for energy and resource efficiency in the economy (EEE)	Financial support	105.4
Finland	Energy Efficiency Agreement of Industry	Voluntary agreement	55.0
Germany	Peak balancing under the Energy Tax Act (EnergieStG) and the Electricity Tax Act (StromStG)	Fiscal	41.0
Germany	Energy efficiency and climate action networks initiative	Information voluntary	33.1
Poland	County heating system	Financial support	6.6
Czech Republic	Modernization Fund 2021-2030 (part industry)	Financial support	5.9
France	Recovery Plan - National Low-carbon strategy - Funds for industry Decarbonization - Energy efficiency component	Financial support	5.7
Italy	Mandatory Energy Audit: Implementation of Directive 2012/27/EU on energy efficiency	Information mandatory	5.3
Netherlands	Accelerated Climate-related Investments in Industry (VEKI)	Financial support	2.8

Source: ODYSSEE-MURE, 2024 (as at 26 March 2025)

The EEE in Germany has several key features that seem to distinguish it from the other large industry measures listed in Table 2:

- **High and increasing funding volume over time, with a rise in triggered investment:** Starting from 100 million euros in 2019 and moving to 1.2 billion euros in 2023, the EEE approved 2.9 billion euros of funding between 2019 and 2023. This resulted in induced investments totalling 9.7 billion euros during the same period, thereof 3.7 billion euros in 2023, showcasing a funding lever of 3.4. In comparison, the Modernization Fund in the Czech Republic allocated 925 million euros from 2021 to 2030, while the Netherlands' VEKI program had 138 million euros from March 2023 to January 2024.
- **Broad range of funded energy efficiency technologies**: The EEE supports a wide range of energy efficiency technologies, including resource efficiency since 2021. In contrast, some programmes in other EU countries are limited to specific target groups, such as Poland's focus on district heating providers, or technologies, such as VEKI in the Netherlands to technologies with significant CO_2 reduction.
- **Technological openness**: The EEE's Module 4 and funding competition show a significant technological openness. Other programmes, such as the Modernisation Fund in the Czech Republic, the Audit programme in Italy and the voluntary agreement in Finland, are also open with regard to the efficiency measures implemented.

- **Wide range of funding options**: The EEE offers a wide range of financing mechanisms, including grants, loans, and competitive funding, which contrasts with other programmes of Table 2 that predominantly rely on grants. For instance, Finland's voluntary agreement utilizes public funds for system administration and monitoring only. None of the programmes in the other countries includes a market/competition component. Among market-based instruments in the EU countries, energy efficiency obligation systems (white certificates), which are mostly designed to be cross-sectoral, dominate.
- **SME-orientation**: In the EEE, approximately three quarters of approvals and half of the subsidies are directed towards small and medium-sized enterprises (SMEs), underlining the programme's intention to also support smaller businesses.
- **Highly adaptive development**: Since 2019, the EEE has demonstrated considerable dynamism in its programme development, with several amendments made to the funding directive including new funding modules and optimised funding opportunities for SMEs as well as an increased focus on electrification and resource efficiency.

Methodology

The evaluation of the EEE is carried out annually along a common methodology originally developed for the energy efficiency fund (Schlomann et al., 2020). This helps to limit variations in the results due to methodological differences in the evaluation approach (e.g. Andrei et al., 2021). This is particularly important when aggregating results for multi-measure schemes with varying technologies and target groups (Hirzel & Schlomann, 2022). Table 3 provides an overview of prior publications related to the EEE and its underlying methodology. The purpose of this methodology is to:

- **Monitor target achievement:** To what extent were the objectives of the funding achieved?
- **Assess impact:** Is the funding the cause of the impact or suitable for triggering it?
- **Control efficiency:** Are both the funding provided (efficiency of implementation) and the objectives achieved (efficiency of measures) in an economical manner?

Table 3. Overview of prior publications related to the EEE and the underlying methodology

Publication	Topic
Schlomann et al. (2017)	A first outline of the general methodology and its application
Voswinkel et al. (2018)	An analysis of the German waste heat programme within the Fund
Voswinkel (2018)	An account of eight ways for determining energy savings in evaluations
Voswinkel (2019)	Catches in evaluations of multi-programme schemes like the Fund
Voswinkel (2020)	Shares the experiences with an overview of a unified harmonization methodology
Hirzel and Schlomann (2022)	Overall impact of the Fund and aggregation issues in multi-measure schemes
Hirzel et al. (2022)	Comparison of the classical vs. the competitive funding line of the EEE
Brunzema et al. (2022)	Ex-ante impact evaluations by the example of the EEE
Weinert et al. (2024)	Resource efficiency as new funding element in the EEE
Hirzel et al. (2024)	Funding of sensors, measurement and control equipment as part of the EEE
Neusel, Hirzel, Weinert, et al. (2024)	Evolution and impact of the EEE from 2019 to 2022

Source: Own compilation based on Neusel, Hirzel, Weinert, et al. (2024)

The evaluation methodology follows a structured nine-step approach as introduced by Hirzel and Schlomann (2022), beginning with (1) the characterisation of the policy measure and (2) the definition of common data and assumptions. This is followed by (3) the identification of programme targets and (4) the selection and operationalisation of indicators. Steps (5) and (6) involve systematic data collection and review, including handling missing or inconsistent information. In step (7), the collected data are analysed to assess progress toward targets. Step (8) focuses on estimating net impacts by identifying and correcting for distortions such as free-rider effects. Finally, step (9) aggregates the individual results to produce an overall assessment and derive conclusions at the programme level.

In this regard, the evaluation of the EEE consists of about 100 individual quantitative and qualitative **key performance indicators** (KPIs). In terms of the overall impact of the EEE, this paper discusses the results along selected quantitative KPIs, categorized by the core evaluation areas described in Table 4. The list includes indicators of general knowledge interest (G) which provide a general characterization for each of the six funding modules. This is followed by KPIs on the target achievement (A), effectiveness (B) and economic efficiency (C). For further details on the overall set of KPIs, the reader is referred to Neusel, Hirzel, Weinert, et al. (2024).

Table 4. Overview of selected groups of key performance indicators relevant to this paper[2]

Indicator	Implementation
(G) - General knowledge interest: Structural data on applications, approvals and funding	
General availment by category	Number of applications/applicants and approvals
Availment by company size	Distribution of approvals/funding by company size [%]
(A) - Target achievement: To what degree have the established targets been achieved?	
Reduction in GHG-emissions	GHG-emission savings by reduction of fuel, electricity and resource consumption [t $CO_{2\text{-eq.}}$]
(B) - Effectiveness: To what degree is the measure causal to the achievements?	
Total value of the effect adjustment (gross to net)	Value of free-rider, pull-forward and spill-over effects
(C) - Economic efficiency: How efficient is the measure from the implementer's perspective with regard to achieving the targets and concerning the use of resources?	
Total costs (funding and admin. costs)	Funding by funding regime and administrative costs [Euro]
Funding efficiency	Funding efficiency relative to GHG-emission reduction [Euro/t $CO_{2\text{-eq.}}$]
Total triggered investments	Triggered investments by funding regime [Euro]
Leverage effect	Ratio: Triggered investments to amount of funding [Euro/Euro]

Source: Own compilation based on Neusel, Hirzel, Weinert, et al. (2024)

The KPIs are mainly based on information from two sources: Major parts use data from programme administration in combination with survey results collected from successful beneficiaries to provide additional insights. Both data sources cover the funding years from 2019 to 2023. The yearly **administrative data** is taken from information contained in the funding databases of the implementing agencies, such as information on the beneficiary (e.g. name, regional allocation, company size) or financial information on the submitted project. For Modules 4 and 5 and the funding competition, information on greenhouse gas and resource savings is also partially available in the administrative data set. Complementary data and views on the funding process from the participants is collected via an annual **online survey** among beneficiaries. The survey consists of common questions for all modules and specific questions addressing aspects of individual modules or implementing agencies. Participation typically takes about 15 to 25 minutes. In the most recent evaluation of 2023, almost 11,000 beneficiaries were invited (response rate around 20 %; similar across the years).

While many of the indicators are determined using the same methods, the **quantification of savings** in category (A) differs by module. For some, especially Module 4 and the funding competition, information on the final energy and resource savings achieved by the funded projects is directly available in the application documents. Within these, applicants use a predefined list of emission factors to calculate their expected CO_2 savings. The EEE is the first energy efficiency funding scheme in Germany to incorporate **resource efficiency,** applying a life cycle assessment (LCA) approach. These resource efficiency projects are characterised by high

[2] A full list of KPIs used for the evaluation of the EEE is provided in the Appendix (Table 5).

absolute GHG reductions (Weinert et al., 2024). GHG savings from resource efficiency measures are calculated using predefined, material-specific CO_2 conversion factors (e.g. in kg CO_2/kg). Applicants determine total CO_2 savings by multiplying these factors by the quantity of material saved (e.g. in kg). For other modules, data from the application database and/or from the survey are used to determine final energy savings, e.g. information about technologies, operating hours and/or nominal powers. Based on the final energy savings calculated for each specific project, greenhouse gas reductions are then derived using defined emission factors, in line with the methodological requirements set out by Schlomann et al. (2020).

To analyse the role of the EEE in triggering investments causing energy and resource savings, gross indicators of category (A) are adjusted by using category (B) values in order to derive net values (Table 4). The latter are determined from online survey. It contains several control questions on the role of the funding scheme for the investment. These questions are used to determine both negative effects (e.g. free-riders for reducing gross values) as well as positive effects (e.g. spill-overs for increasing gross values) (Schlomann et al., 2017). The EEE's evaluation considers the **free-rider** and **spill-over effect**. The former mirrors the share of investments/savings that would also have occurred in the absence of the EEE or that were already planned for a later date (pull-forward effect). The spill-over effect describes investments/savings triggered as a result of the EEE but not receiving any funding. In other words, the programme can make others receptive to similar or related energy efficiency actions. This can lead to further investment in other measures. A survey-based approach similar to the EEE's predecessor programme is used to calculate these effects (Voswinkel, 2018). For 2023, the **effect adjustment** reduces gross values by around 12 percentage points across all six funding modules.

For further details on the overall methodology and methodological challenges, the reader is referred to Hirzel and Schlomann (2022), Voswinkel (2018), Voswinkel (2019), Voswinkel (2020) aKlicken oder tippen Sie hier, um Text einzugeben.nd Hirzel and Schlomann (2022).

Results and Discussion

Overall impact: KPIs of the five-year evaluation from 2019 to 2023[3]

Applications, approvals and funding volume

The increasing funding volume over time is accompanied by an increase in induced investments (Figure 2; Table 6, Appendix). The programme also underwent an upward trajectory with regard to the number of applications and approvals. Thereby, it should be noted that the entire EEE was temporarily suspended in December 2023 due to a governmental budget freeze following a ruling by the Federal Constitutional Court (BAFA, 2023). This led to a cessation in funding approvals in December 2023. On the other hand, increased processing capacity at the administrative offices of the implementing agencies compared to 2022 increased processing figures in 2023. This helped to partially reduce a temporary application backlog. When analysing applications and approvals, it is important to consider processing times. Applications submitted towards the end of a year may not be approved until the beginning of the next year. For the evaluation, this means that some effects - such as changes of funding conditions or introductions of new modules - only take effect with a certain delay.

On the level of the individual modules, Module 1, which is dominated by SMEs, accounts for most of the approvals across all years by far (65 per cent), followed by Module 4 (27 per cent) (Figure 2). Half of the funding and around two-thirds of the investments triggered are attributable to the dominant Module 4. This can be explained by substantially larger projects in Module 4 than in Module 1 due to its systemic and technology-open focus. Recently, the funding competition witnessed the strongest growth, with the number of applications

[3] A detailed table of KPIs for categories G, A and C at module level and for the overall programme over time is provided in the Appendix (Table 6).

doubling in 2023 (102) compared to 2022 (61). This can be explained by a procedural change in the competition[4]. The application figures for Module 5 (transformation plans), which was evaluated for the first time in 2023, have been higher than originally expected (Löwenstein et al., 2025). The new Module 6 (electrification in micro and small enterprises), which only started in May 2023, has also been in demand (Hirzel et al., 2025).

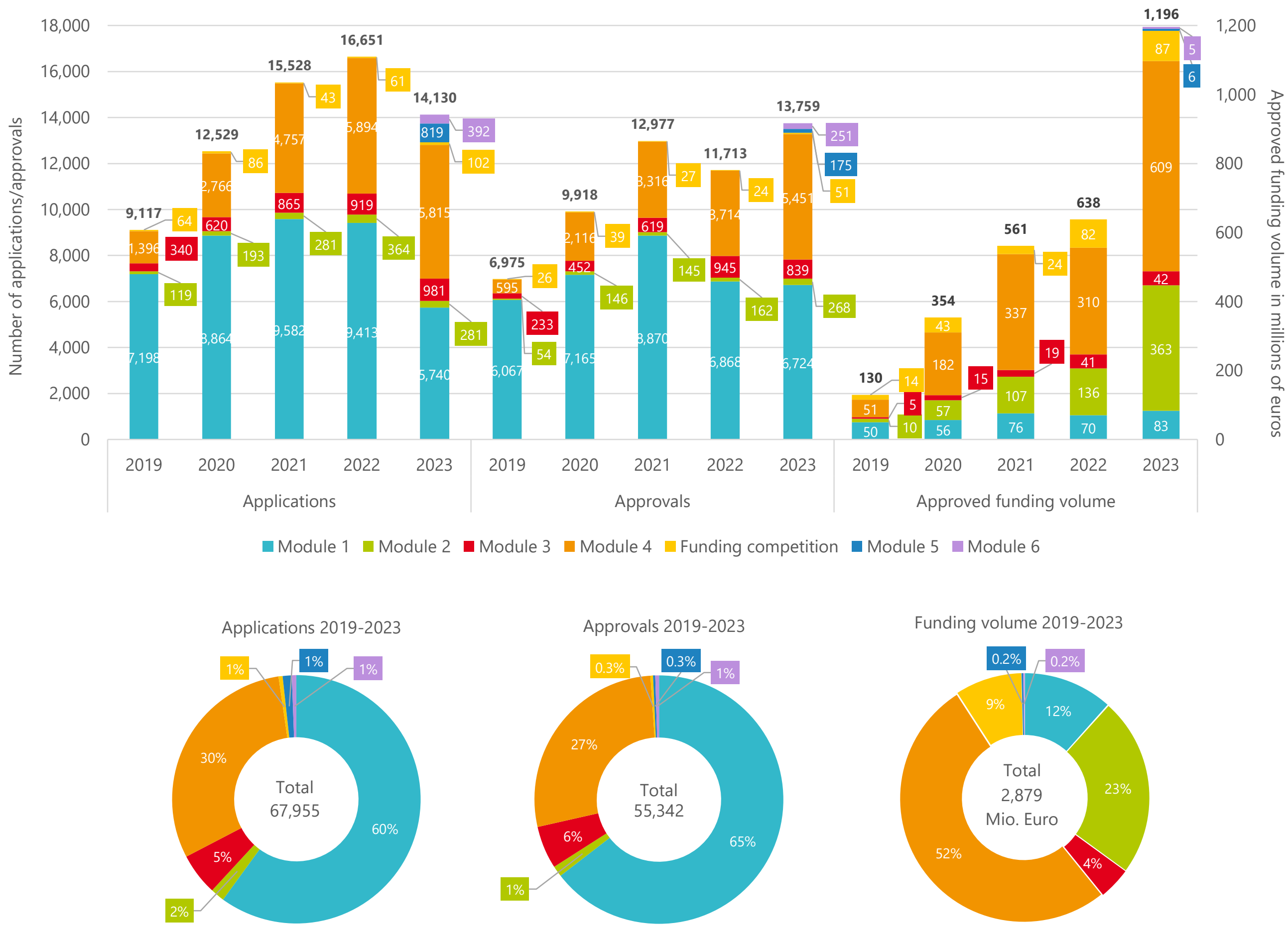

Figure 2. Applications, approvals and funding volume of the overall EEE and its modules between 2019 and 2023. *Source:* Own compilation based on administrative data.

Regarding availment by company size, SMEs accounted for around three quarters of approvals. However, they only accounted for around half of the total funding. This is primarily due to the significantly larger projects in Module 4 and the funding competition, as well as some in Module 2, which are in demand by large companies.

In terms of regions, across all years, the EEE is dominated by participants from the large federal states of North Rhine-Westphalia, Baden-Württemberg and Bavaria, both in terms of approvals and funding. Possible reasons for this regional focus - in addition to the high economic output of these states - are the activities of energy and efficiency agencies and energy efficiency networks.

Regarding the use of funding options, it seems that although the loan option accounts for only 2 percent of approvals, the different funding options cover different company needs. According to the accompanying survey, companies with sufficient equity prefer grants, while larger companies and projects tend to rely on loans

[4] To guarantee the competitive character, the new procedure envisages that a certain share (20 per cent) of losers will be generated, provided that the round budget is not fully utilized. As a result, a greater number of projects in total have taken part in the competition in 2023. This also had a positive influence on the number of SMEs.

or funding competitions. This suggests that the choice of funding options is substantially influenced by the administrative requirements, the risks and the financial situation of the companies.

Overall, the results imply that the programme has been successively expanded since its start is. This seems to support the idea that time for the deployment of a funding programme is needed. However, over time, as in the case of Module 1, a market saturation may occur for certain technologies. For instance, the funding of over 30,000 air compressors in Module 1 over a five-year period likely indicates that a substantial number of outdated and inefficient units have already been replaced.

Estimated reduction in GHG-emissions

Since the EEE came into force and until the end of 2023, the entire programme (excluding Module 5[5]) achieved calculated gross saving in GHG emissions of just short of annually 7 million tonnes of $CO_{2\text{-eq}}$ (Figure 3). Of this, about 25 per cent are attributable to electricity savings, about 65 per cent to fuel savings and around 10 per cent to savings through resource efficiency. The distribution between electricity and fuels has shifted in favour of fuels over the years. In absolute terms, the savings in all years are dominated by the technology-open Module 4 (65 per cent).

Since November 2021, resource efficiency projects have been eligible in Module 4 and the funding competition. Overall, the resource efficiency funding element became established and is responsible for a substantial share of the GHG savings in 2022 and 2023, particularly in the funding competition (light yellow/orange in Figure 3). For the latter, a trend towards smaller projects in 2023 led to lower overall savings compared to the exceptional year 2022, which was dominated by two large projects. In terms of resource savings, Weinert et al. (2024) find that the resources saved are heterogeneous including primary metal, water, stainless steel sheet, polypropylene and paper. Yet, in their discussion of the methodological allocation of resource savings within the EEE, Weinert et al. (2024) note that the GHG reduction effect of resource efficiency measures from imported resources does not necessarily take place in the country where it has been triggered.

In summary, the savings achieved through the programme have increased successively since its launch, making the EEE the leading measure among all EU countries when it comes to promoting energy efficiency in industry (Table 2). The combination of multiple measures in a single programme, including a substantial technology-open component and the integration of resource efficiency, appears to be a key feature here.

Although tailored approaches were used to determine the calculated savings by module and based on technology data, several limitations need consideration: Information on disbursed funding is reliable because it is based on administrative processes. In contrast, the data in application documents—for example on energy demand, savings, or the distribution across different energy carriers—is often less reliable. When complementary data from surveys is used to determine savings, it is essential to be aware of non-response and response bias as limitations. It is also important to acknowledge that a relevant gap may exist between the submission of funding applications and the subsequent execution of the associated measures. Applicants may opt not to proceed with a project or may modify its implementation in ways that deviate from the original proposal after the actual completion of the ex-post evaluation. As a result, ex-post evaluations often face problems with data. The data is sometimes not very meaningful and is only available for a limited number of cases and measures.

[5] Since the transformation plans from Module 5 only include planned measures, so called conceptual savings, these are not integrated at this point.

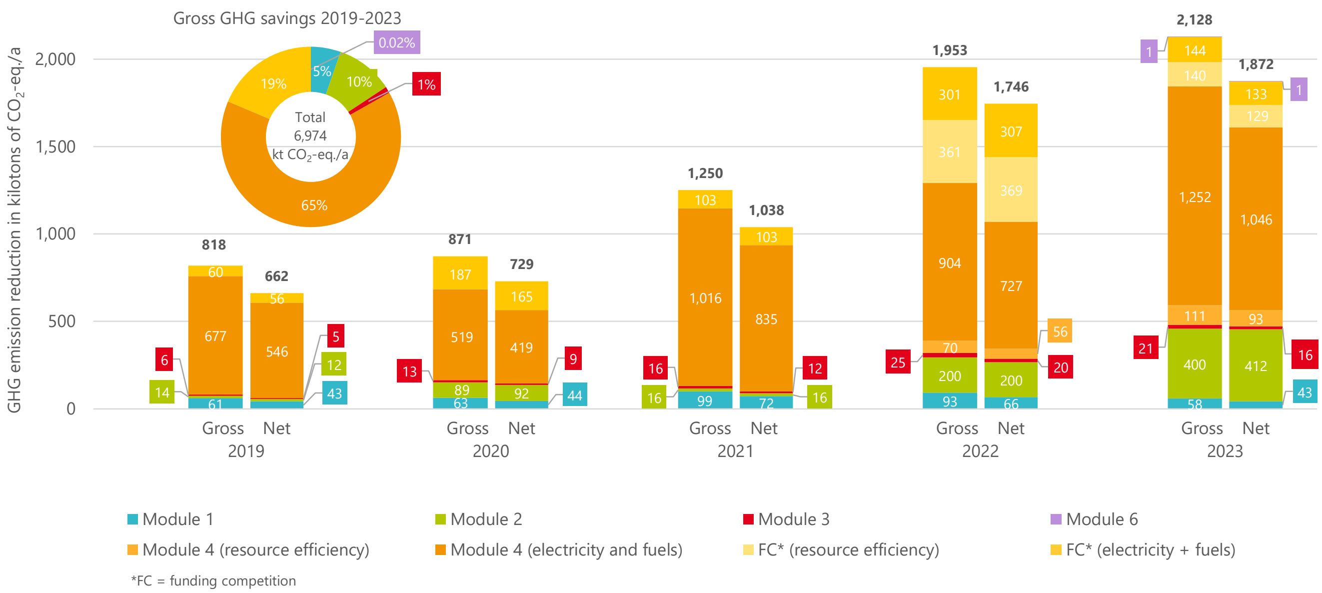

Figure 3. Estimated reduction in GHG-emissions (gross and net[6]) of the overall EEE and its modules between 2019 and 2023. *Source:* Own compilation based on administrative and survey data.

GHG- funding efficiency

The central indicator of economic efficiency is the GHG funding efficiency. In line with the methodology guideline (Schlomann et al., 2020), this is defined as the "ratio between the resources used (funding including administrative costs) and the GHG emission reduction determined over the lifetime[7]". In the EEE, there is a wide variation in funding efficiencies between the modules (Figure 4). This is largely due to the diversity of the funded items and the target groups. For example, over the entire period from 2019 to 2023, the funding efficiency of Module 4 is 42 euro per tonne of CO_2 for an assumed lifetime of 8 years, while it is 113 euro per tonne of CO_2 for Module 1 with the same assumed lifetime. Among other factors, this can be attributed to the fact that Module 4 finances significantly larger projects than Module 1 due to its technology-open focus. In addition, Module 1 is mostly dominated by SMEs and funds smaller cross-cutting measures. The findings suggest that from a purely monetary perspective, the funding of Module 4 appears much more effective. A focus on this value would neglect, however, particularities of the other modules (e.g. less complex measures, low-level entry point for other modules). In general, it should be noted that the interpretation of the funding efficiency should always take into account the specific characteristics of a measure (Schlomann et al., 2020). Important factors include the type and size of the measure, its target group, the addressed saving potential as well as the long-term nature of the induced energy efficiency measure.

Overall, it can be inferred that the technology-open funding approach, exemplified by Module 4 and the funding competition, yields substantial savings primarily due to the large-scale projects that it supports. While this approach demonstrates superior funding efficiency, the continued relevance of technology-focused funding opportunities remains justified. On one hand, technology-focused funding has proven successful in attracting a high volume of applications, attributed to a streamlined application process, especially for cross-cutting technologies considered as 'low-hanging fruits'. On the other hand, the role of a low-level entry point as a 'door-

[6] The EEE evaluation accounts for free-rider and spill-over effects when deriving net values from gross results (see methodology section, Table 4)

[7] To determine the lifetime of the measures, values provided by Commission Recommendation (EU) 2019/1658 on transposing the energy savings obligations under the Energy Efficiency Directive (2019) for different sectors and technical measures are used, in line with Schlomann et al. (2020).

opener' should not be underestimated. Technology-specific funding as provided in Module 1, for example, facilitates subsequent applications in more complex modules. A similar effect is observed with the conceptual funding of transformation plans in Module 5.

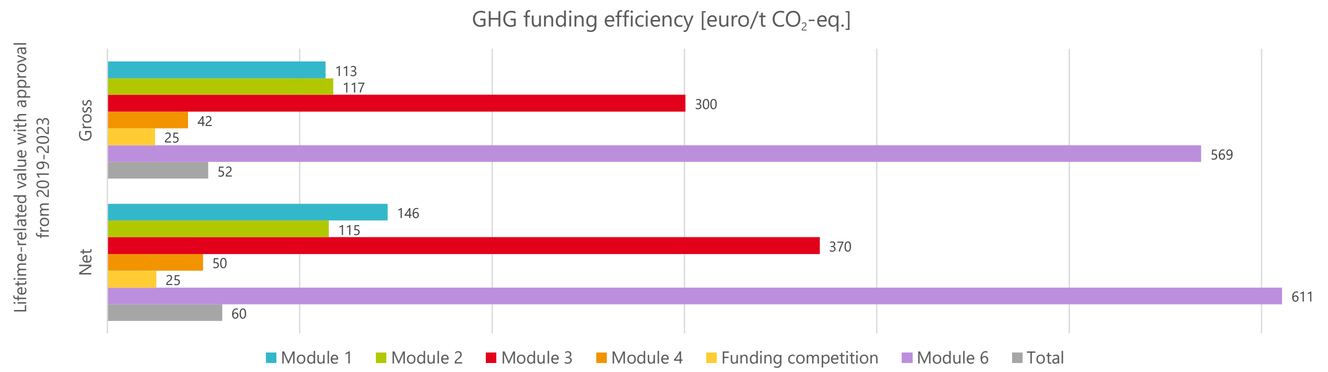

Figure 4. Lifetime-related GHG funding efficiency (gross and net) of the overall EEE and its modules between 2019 and 2023. *Source:* Own compilation based on administrative and survey data.

Leverage effect

Starting from 100 million euros in 2019, between 2019 and 2023, the EEE approved funding of 2.9 billion euros, with 1.2 billion euros allocated in 2023 alone. This resulted in induced investments totalling 9.7 billion euros during the same period, thereof 3.7 billion euros in 2023, showcasing a funding lever of 3.4 (Figure 5). Like funding efficiency, funding leverage varies across the modules due to their different characteristics.

The development in 2023 is especially noteworthy. In 2023, a substantial increase in funding (+87 per cent compared to 2022) and investments (+76 per cent) was recorded (Table 6, Appendix). Half of the funding and around two thirds of the investments triggered in 2023 are attributable to the dominating Module 4. In this module, the volume of funding granted in 2023 almost doubled compared to 2022 (Figure 1). In addition to the increased demand, this is likely due to a change in the funding regime. Half of the funding volume in 2022 was approved in accordance with the funding guideline from February 2020 (GHG cap for SMEs: €700/t CO_2). This guideline no longer played a role in 2023 (GHG cap for SMEs: mainly €900/t CO_2). All other modules also recorded an increase in funding and investments in 2023. One possible explanation is price increases, such as in the area of compressed air systems in Module 1. It is also conceivable that funding cases tend to become more complex and therefore more expensive, meaning that low-hanging fruits have been increasingly harvested over the years.

In sum, the funding lever/cost-effectiveness of a programme is affected by a multitude of factors encompassing alterations in funding conditions and priorities, as well as increasing prices. Moreover, there are certain limitations on the allocation of funding and investment within an evaluation: in cases where the implementation of the funded project is finalized and approved, the spent funding is well-known. For the remaining cases still under implementation, the requested funding is only available as tentative value in the application documents. While in theory, a summative evaluation should be conducted after implementation, practical implementation processes take their time, especially in case of complex measures. Therefore, it is generally not feasible to conduct ex-post evaluations exclusively on completed projects.

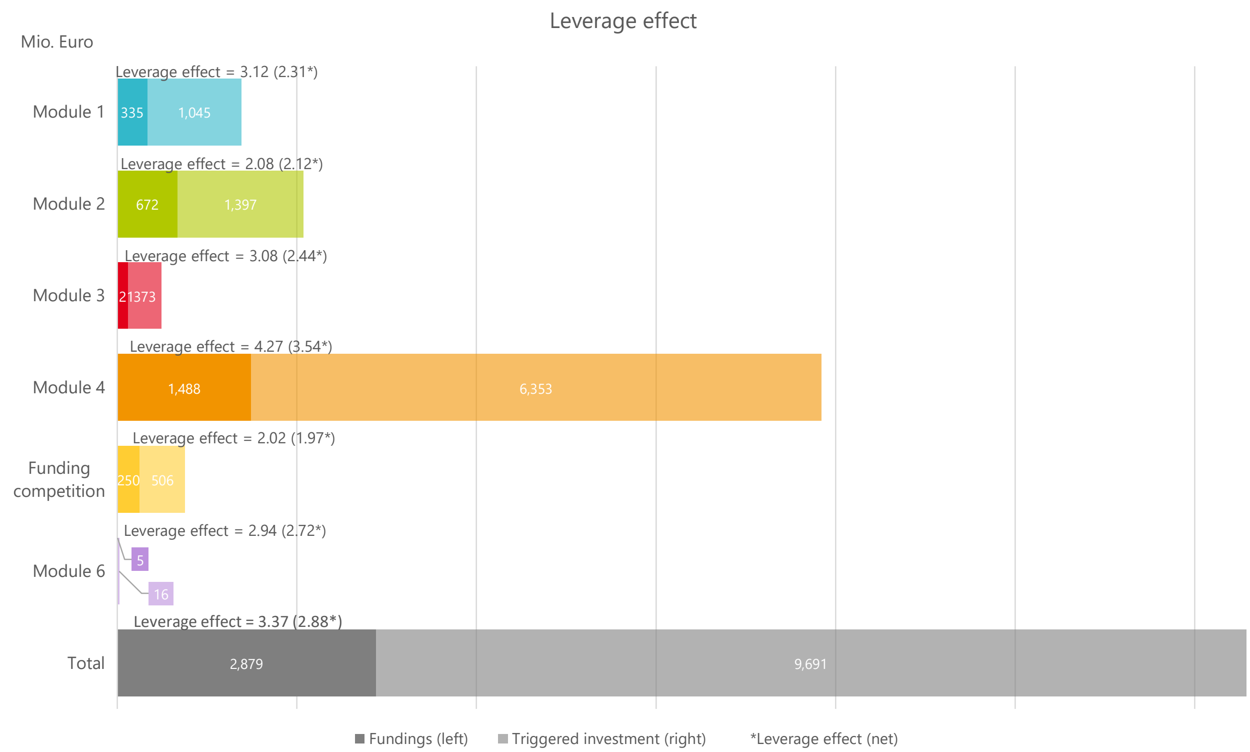

Figure 5. Leverage effect (gross and net) of the overall EEE and its modules between 2019 and 2023. *Source:* Own compilation based on administrative data.

Recommendations based on the evaluation

The results suggest that the programme is well underway and the KPI do not reveal any substantial need for structural revisions. So, w*hat can we learn from the evaluation results for future energy and resource efficiency programmes?* Based on the evaluation experience, five groups of recommendations emerge (Figure 6).

To begin with, it is essential to **align programme goals and ambition levels**. Establishing a lean target system with realistic objectives facilitates to understand and adjust the programme. It is important to realize that in case of multiple objectives, optimization in one area may inadvertently affect others. During the evaluation of the EEE, for example, it became evident that for modules involving electrification, such as Modules 2 and 6, considering final energy savings as objectives does not cover changes in energy carriers. It is advisable to define an overarching common goal, for example in terms of GHG reductions, in addition to the goals of individual modules. Setting specific targets for SMEs can lead to lower funding efficiency because SMEs usually achieve lower emission savings per project than large companies. It also needs be taken into account that, after the low-hanging fruits have been harvested, subsequent projects are typically more complex and expensive. Recognizing these complexities is crucial for establishing realistic targets. Furthermore, it is important to adapt technology-specific minimum efficiency requirements regularly (such as for compressed air systems and other technologies in Module 1) to limit free-rider effects, ensuring that funding is directed toward genuinely impactful measures.

Next, a stable **funding environment** with appropriate amendment deadlines is helpful to provide clarity and predictability for applicants. For example, in the EEE, the frequency of revisions has tended to increase compared to the early years, with only five months between the latest revisions (Neusel, Hirzel, Weinert, et al., 2024). This makes it difficult for funding recipients to keep track of changes. Also, an attractive presentation of the programme relying on modern formats, ensuring that information is easily digestible, is helpful. For instance, respondents to the survey have proposed the simplification of complex guidelines and fact sheets as a means of facilitating easier access within the EEE. From the implementers' perspective, shorter processing times can only be achieved if there is enough capacity and expertise to review funding applications. This also helps to streamline the application process. Finally, providing targeted assistance for SMEs and specific sectors could further optimize participation.

Furthermore, **thinking about evaluation** when designing a funding programme is crucial. Greater consideration of evaluation within the programme framework can lead to an improved quality of the analysis. An evaluation-compliant database structure with plausibility checks can improve data quality. For example, it can detect input errors related to units and help close data gaps, such as those concerning savings or technology categories.

Another important aspect is **strengthening multipliers to spread information on programmes more widely**. Engaging those that professionally prepare funding requests, e.g. energy advisors, can help to reach hard-to-access groups. For instance, in some modules of the EEE, low-hanging fruits might have been harvested within one technological area while there still appear to be untapped potential in others. Activating new multipliers in these domains can contribute to increasing demand for the programme. It is also beneficial to explore new communication channels, such as social media, and to collaborate with advocates like chambers of commerce and energy efficiency agencies to increase visibility and participation in a programme. Additionally, there is a constant need to increase utilization in underrepresented regions and industries, also in the EEE. Targeted efforts to engage these areas could help ensure that the benefits of the programme are equitably distributed.

Lastly, the **design** of the EEE shows that combining technology-specific and technology-open funding opportunities can meet diverse needs. This approach enables programmes to support a wider range of projects and target groups. Offering various funding models - such as grants, loans, and competition-based funding - can encourage participation across different project types. From a practical perspective, longer implementation times could benefit complex projects. They would provide greater planning certainty and allow for more thorough project development and execution. From a methodological perspective, clear guidelines for accounting the GHG impact of imported resources are needed with regard to programme credibility. Finally, it is also important to emphasize good integration with other programmes to make it easier for applicants to navigate available resources.

Align goals and ambition level

- Lean and focused target system improves optimisation potential and increases control capability
- Realistic targets: after low hanging fruit usually come more complex/expensive projects
- Check technology-specific minimum requirements (e.g. compressed air) to limit free-rider effects

Funding environment, improved realisation and presentation

- Stable funding environment and appropriate amendment deadlines
- Reduce the complexity of guidelines and information sheets
- Attractive presentation and modern forms for simplified access
- Shorter processing times: Provision of sufficient capacity and experts for the review of funding applications
- Targeted assistance for SMEs and specific sectors

Thinking about evaluation

- Evaluation-compliant database structure
- Improvement of data quality through plausibility checks during input (e.g. units)
- Closing data gaps (e.g. for savings or technology categories)

Strengthening multipliers and spreading programmes more widely

- Use project collectors and repeat applicants as leverage for disseminating and tapping into hard-to-reach groups
- Increase utilisation in underrepresented regions/industries
- Exploration of new channels (social media) and utilizatoin of advocates (e.g. chambers of commerce, energy agencies)

Recommendations for programme design

- Technology-specific as well as technology-open funding opportunities
- Various funding models depending on applicants' needs (grant, loan, competition)
- Better integration with other programmes
- Complex projects: extension of the call-off period for more planning certainty
- Resource efficiency: methodical handling of the GHG impact of imported resources

Figure 6. Recommendations from the evaluation. *Source:* Own illustration.

Conclusions

This paper aimed to extend the empirical evidence on evaluations of funding schemes for industrial energy efficiency by presenting the results of a five-year ex-post evaluation of the Federal Funding Scheme for Energy and Resource Efficiency in the Economy (EEE) from 2019 to 2023. From the evaluation experience several key findings are derived that can be helpful for future energy and resource efficiency programmes.

The overall analysis of KPIs of the EEE does not reveal any substantial need for structural revisions, especially concerning important KPI such as greenhouse gas savings and funding efficiency. The EEE is characterized by a high and increasing funding volume over time, it covers a broad range of funding mechanisms for different technologies and has a wide range of funding options. Over a period from 2019 to 2023, it offered about 2.9 billion euros of funding and supported investments of 9.7 billion euros. During the same period, the EEE achieved calculated gross GHG savings of just short of annually 7 million tonnes of $CO_{2\text{-eq}}$. Of these, about 25 per cent are attributable to electricity savings, about 65 per cent to fuel savings and around 10 per cent to savings through resource efficiency.

In a broader perspective towards future energy and resource efficiency programmes, the evaluation yields several insights: It highlights the importance of establishing a streamlined target system with realistic objectives to prevent trade-offs and side-effects when optimizing for individual goals. A stable funding environment also appears to be essential for ensuring clarity and predictability for applicants, while short processing times and simple guidelines can help to enhance accessibility. Importantly, the evaluation underscores the dual validity of both technology-open and technology-focused funding approaches. While the former is beneficial for achieving significant savings, the latter fosters broader engagement and facilitates future funding opportunities. Ultimately, the insights gained from this evaluation provide valuable guidance for the development of future energy and resource efficiency programs, ensuring that they effectively address diverse needs.

Acknowledgements

This paper is based on results of a project carried out for the German Federal Ministry for Economic Affairs and Climate Action (BMWK). We express our gratitude to the representatives from the Ministry and the implementing agencies for their support, our colleagues from Prognos, University of Stuttgart IER and Öko-Institut working on the study.

References

Abeelen, C. J., Harmsen, R [R.], & Worrell, E [E.] (2019). Disentangling industrial energy efficiency policy results in the Netherlands. *Energy Efficiency*, *12*(5), 1313–1328. https://doi.org/10.1007/s12053-019-09780-4

Anderson, S. T., & Newell, R. G. (2004). Information programs for technology adoption: the case of energy-efficiency audits. *Resource and Energy Economics*, *26*(1), 27–50. https://doi.org/10.1016/j.reseneeco.2003.07.001

Andersson, E., Arfwidsson, O., Bergstrand, V., & Thollander, P. (2017). A study of the comparability of energy audit program evaluations. *Journal of Cleaner Production*, *142*, 2133–2139. https://doi.org/10.1016/j.jclepro.2016.11.070

Andersson, E., Karlsson, M., Thollander, P., & Paramonova, S. (2018). Energy end-use and efficiency potentials among Swedish industrial small and medium-sized enterprises – A dataset analysis from the national

energy audit program. *Renewable and Sustainable Energy Reviews*, *93*, 165–177. https://doi.org/10.1016/j.rser.2018.05.037
Andrei, M., Thollander, P., Pierre, I., Gindroz, B., & Rohdin, P. (2021). Decarbonization of industry: Guidelines towards a harmonized energy efficiency policy program impact evaluation methodology. *Energy Reports*, *7*, 1385–1395. https://doi.org/10.1016/j.egyr.2021.02.067
Backlund, S., & Thollander, P. (2015). Impact after three years of the Swedish energy audit program. *Energy*, *82*, 54–60. https://doi.org/10.1016/j.energy.2014.12.068
Bahn-Walkowiak, B., & Wilts, H. (2017). The institutional dimension of resource efficiency in a multi-level governance system—Implications for policy mix design. *Energy Research & Social Science*, *33*, 163–172. https://doi.org/10.1016/j.erss.2017.09.021
Richtlinie zur Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft – Förderwettbewerb, Bundesanzeiger 1 (2024).
Richtlinie zur Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft – Zuschuss und Kredit, Bundesanzeiger 1 (2024).
Brunzema, I., Schlomann, B., & Kemmler, A. (2022). *How to increase the transparency of ex-ante impact evaluations of energy efficiency and climate policies. Illustrated by the example of a funding program for energy and resource efficiency in industry in Germany.* https://doi.org/10.24406/publica-1038
Domenech, T., & Bahn-Walkowiak, B. (2019). Transition Towards a Resource Efficient Circular Economy in Europe: Policy Lessons From the EU and the Member States. *Ecological Economics*, *155*, 7–19. https://doi.org/10.1016/j.ecolecon.2017.11.001
Economidou, M., Ringel, M., Valentova, M., Castellazzi, L., Zancanella, P., Zangheri, P., Serrenho, T., Paci, D., & Bertoldi, P. (2022). Strategic energy and climate policy planning: Lessons learned from European energy efficiency policies. *Energy Policy*, *171*, 113225. https://doi.org/10.1016/j.enpol.2022.113225
Energistyrelsen. (2022). *Erhvervstilskud til energieffektiviseringer*. https://ens.dk/ansvarsomraader/energibesparelser/virksomheder/erhvervstilskud-til-energieffektiviseringer
Commission Recommendation (EU) 2019/1658 on transposing the energy savings obligations under the Energy Efficiency Directive, Official Journal of the European Union 1 (2019).
Fleiter, T., Gruber, E., Eichhammer, W., & Worrell, E [Ernst] (2012). The German energy audit program for firms—a cost-effective way to improve energy efficiency? *Energy Efficiency*, *5*(4), 447–469. https://doi.org/10.1007/s12053-012-9157-7
Harmelink, M., Nilsson, L., & Harmsen, R [Robert] (2008). Theory-based policy evaluation of 20 energy efficiency instruments. *Energy Efficiency*, *1*(2), 131–148. https://doi.org/10.1007/s12053-008-9007-9
Harris, J., Anderson, J., & Shafron, W. (2000). Investment in energy efficiency: a survey of Australian firms. *Energy Policy*, *28*(12), 867–876. https://doi.org/10.1016/S0301-4215(00)00075-6
Heinrich, S., Langreder, N., Thormeyer, C., Seefeldt, F., Brischke, L.-A., & Pehnt, M. (2019). *Ex post-Analyse des Pilotprogramms STEP up! Bericht. Beitrag zur Erfolgskontrolle finanzwirksamer Maßnahmen für das Pilotprogramm „Stromeinsparungen im Rahmen wettbewerblicher Ausschreibungen: Stromeffizienzpotentiale nutzen" (STEP up!)*. BfEE 02/2016. Prognos; ifeu. https://www.bmwk.de/Redaktion/DE/Evaluationen/Foerdermassnahmen/pilotprogramm-stromeinsparungen-im-rahmen-wettbewerblicher-ausschreibungen-stromeffizienzpotentiale-nutzen-step-up.pdf?__blob=publicationFile&v=8
Herce, C., Martini, C., Toro, C., Biele, E., & Salvio, M. (2024). Energy Efficiency Policies for Small and Medium-Sized Enterprises: A Review. *Sustainability*, *16*(3), 1023. https://doi.org/10.3390/su16031023
Hirzel, S., Berger, C., & Neusel, L. (2024). A measure of control: About sensors, measurement and control equipment in German companies. In *Proceedings of the eceee summer study 2024.* https://doi.org/10.24406/publica-3346

Hirzel, S., Löwenstein, A., Neusel, L., & Radgen, P. (2025). *Forklifts at the Forking Point: Evaluating Technology Open Funding Schemes with Dominating Technologies: Draft submission to the Energy Evaluation Europe Conference 2025.*

Hirzel, S., Neusel, L., Heinrich, S., Weinert, K., & Schlomann, B. Evaluation of the German Funding Scheme for Energy Efficiency in the Economy: Classical versus Competitive Financial Measures. In *Energy Evaluation Europe Conference 2022.* https://doi.org/10.24406/publica-1037 (Original work published 2022)

Hirzel, S., & Schlomann, B. (2022). Evaluating Multi-measure Schemes for Enhancing Energy Efficiency: The German Energy Efficiency Fund. In *Proceedings of the eceee summer study 2022.*

Johansson, I., Johnsson, S., & Thollander, P. (2022). Impact evaluation of an energy efficiency network policy programme for industrial SMEs in Sweden. *Resources, Environment and Sustainability*, *9*, 100065. https://doi.org/10.1016/j.resenv.2022.100065

Johansson, I., Mardan, N., Cornelis, E., Kimura, O., & Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, *12*(7), 1338. https://doi.org/10.3390/en12071338

Locmelis, K., Blumberga, D., Blumberga, A., & Kubule, A. (2020). Benchmarking of Industrial Energy Efficiency. Outcomes of an Energy Audit Policy Program. *Energies*, *13*(9), 2210. https://doi.org/10.3390/en13092210

Löwenstein, A., Radgen, P., Ludig, S., & Nissen, C. (2025). *Scope, scale and strategy: Insights from the evaluation of company specific decarbonization plans: Draft submission to the Energy Evaluation Europe Conference 2025.*

Mills, E. (1991). Evaluation of European lighting programmes. *Energy Policy*, *19*(3), 266–278. https://doi.org/10.1016/0301-4215(91)90151-D

Neusel, L., Hirzel, S., Heinrich, S., Berger, C., Weinert, K., Grodeke, A.-M., Kulkarni, P., Radgen, P., Löwenstein, A., Schumacher, K., Nissen, C., Ludig, S., & Hünecke, K. (2024). *Evaluation der „Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft“ (Zuschuss und Kredit/Förderwettbewerb): Projekt für das Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) - Referat 123 / Projekt BfEE 08/2020*. Jahresbericht 2023. Fraunhofer ISI, Prognos, Universität Stuttgart, Öko-Institut. https://www.bmwk.de/Redaktion/DE/Evaluationen/Foerdermassnahmen/241217-evaluation-eew-jahresbericht-2023.pdf?__blob=publicationFile&v=6

Neusel, L., Hirzel, S., Weinert, K., Heinrich, S., & Grodeke, A.-M. (2024). Efficiency Unleashed: Evolution and Impact of Germany's Funding Scheme for Energy and Resource Efficiency in the Economy. In *Proceedings of the eceee summer study 2024.*

ODYSSEE-MURE. (2024). *2024 EU Energy Efficiency scoreboard*. https://www.odyssee-mure.eu/data-tools/scoring-efficiency-countries.html

Paramonova, S., & Thollander, P. (2016). Ex-post impact and process evaluation of the Swedish energy audit policy programme for small and medium-sized enterprises. *Journal of Cleaner Production*, *135*, 932–949. https://doi.org/10.1016/j.jclepro.2016.06.139

Parsons, D. W. (2003). *Public policy: An introduction to the theory and practice of policy analysis* (Paperback ed., repr). Elgar.

Patel, M. K [Martin K.], Broc, J.-S., Cho, H., Cabrera, D., Eberle, A., Federici, A., Freyre, A., Jeanneret, C., Narula, K., Oikonomou, V., & Yilmaz, S. (2021). Why We Continue to Need Energy Efficiency Programmes—A Critical Review Based on Experiences in Switzerland and Elsewhere. *Energies*, *14*(6), 1742. https://doi.org/10.3390/en14061742

Radgen, P., Bisang, K., & Koenig, I. (2016). Competitive tenders for energy efficiency – lessons learnt in Switzerland. In *Proceedings of the eceee industrial summer study 2016* (pp. 81–89).

Safarzadeh, S., Rasti-Barzoki, M., & Hejazi, S. R. (2020). A review of optimal energy policy instruments on industrial energy efficiency programs, rebound effects, and government policies. *Energy Policy*, *139*, 111342. https://doi.org/10.1016/j.enpol.2020.111342

Schlomann, B., Hirzel, S., Nabitz, L., Heinrich, S., Jessing, D., Paar, A., Pehnt, M., & Antoni, O. (2017). From Targets to Impacts: Eight Steps for Evaluating Energy Efficiency Policies. In *International Energy Program Evaluation Conference - IEPEC 2017. Making Ambitious Reductions Real: Accurate and Actionable Evaluation,* Baltimore.

Schlomann, B., Voswinkel, F., Hirzel, S., Paar, A., Jessing, D., Heinrich, S., Antoni, O., & Kahles, M. (2020). *Methodikleitfaden für Evaluationen von Energieeffizienzmaßnahmen des BMWi (Projekt Nr. 63/15 - Aufstockung).* Fraunhofer ISI; Prognos AG; ifeu; Stiftung Umweltenergierecht. https://www.bmwi.de/Redaktion/DE/Downloads/M-O/methodik-leitfaden-fuer-evaluationen-von-energieeffizienzmassnamen.pdf?__blob=publicationFile&v=6

Stenqvist, C., & Nilsson, L. J. (2012). Energy efficiency in energy-intensive industries—an evaluation of the Swedish voluntary agreement PFE. *Energy Efficiency*, *5*(2), 225–241. https://doi.org/10.1007/s12053-011-9131-9

Tanaka, K. (2008). Assessment of energy efficiency performance measures in industry and their application for policy. *Energy Policy*, *36*(8), 2887–2902. https://doi.org/10.1016/j.enpol.2008.03.032

Tanaka, K. (2011). Review of policies and measures for energy efficiency in industry sector. *Energy Policy*, *39*(10), 6532–6550. https://doi.org/10.1016/j.enpol.2011.07.058

Thollander, P., Danestig, M., & Rohdin, P. (2007). Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs. *Energy Policy*, *35*(11), 5774–5783. https://doi.org/10.1016/j.enpol.2007.06.013

Thollander, P., & Dotzauer, E. (2010). An energy efficiency program for Swedish industrial small- and medium-sized enterprises. *Journal of Cleaner Production*, *18*(13), 1339–1346. https://doi.org/10.1016/j.jclepro.2010.04.020

Valentová, M., Lízal, L., & Knápek, J. (2018). Designing energy efficiency subsidy programmes: The factors of transaction costs. *Energy Policy*, *120*, 382–391. https://doi.org/10.1016/j.enpol.2018.04.055

Voswinkel, F. (2018). Accounting of energy savings in policy evaluation. How to get a least 8 different (correct!) results from the same data. In *IEPPEC International Energy Policy and Programme Evaluation Conference,* Vienna, Austria.

Voswinkel, F. (2019). Gotta catch 'em all - catches to evaluating heterogenous energy efficiency programmes. In *Eceee 2019 Summer Study on Energy Efficiency: Is Efficient Sufficient? Eceee Summer Study proceedings* (pp. 767–776). eceee.

Voswinkel, F. (2020). One size fits all? Emerging challenges to harmonising energy efficiency evaluations in a changing policy arena. In *Energy Evaluation Europe: Accelerating the energy transition for all: Evaluation's role in effective policy making,* Here East, Olympic Park, London.

Voswinkel, F., Grahl, A., & Rohde, C. (2018). Less hot air for a less hot climate: evaluating the German waste heat reduction programme. In *Proceedings of the eceee Industrial Summer Study 2018,* Kalkscheune, Berlin, Germany.

Weinert, K., Neusel, L., & Hirzel, S. (2024). Resource efficiency: A new element in Germany's funding program for companies. In *Proceedings of the eceee summer study 2024.* https://doi.org/10.24406/publica-3350

Weiss, C. H. (1998). *Evaluation: Methods for studying programs and policies* (2. ed.). Prentice Hall.

Wilts, H., & O'Brien, M. (2019). A Policy Mix for Resource Efficiency in the EU: Key Instruments, Challenges and Research Needs. *Ecological Economics*, *155*, 59–69. https://doi.org/10.1016/j.ecolecon.2018.05.004

Yushchenko, A., & Patel, M. K [Martin Kumar] (2017). Cost-effectiveness of energy efficiency programs: How to better understand and improve from multiple stakeholder perspectives? *Energy Policy*, *108*, 538–550. https://doi.org/10.1016/j.enpol.2017.06.015

Appendix

Table 5. Overview of key performance indicators for the evaluation of the EEE

Indicator	Implementation
(G) - General knowledge interest: Structural data on applications, approvals and funding	
G1/G2: General availment	Number of applications/applicants, rejections, approvals and cancellations
G3: Availment by region	Regional distribution of approvals/funding at state level and relative to number of companies/GDP [%]
G4: Availment by type of applicant	Distribution of approvals/funding by contractors/direct applicants [%]
G5: Availment by type of company	Distribution of approvals/funding by private/municipal companies [%]
G6: Availment by company size	Distribution of approvals/funding by company size [%]
G7: Availment by sector	Distribution of approvals/funding by sector and relative to number of companies/turnover [%]
G8: Availment by funding object	Distribution of approvals by funding object (module specific) [%]
G9: Availment by funding regime	Distribution of approvals/funding by funding regime (GBER/De-minimis), share of approvals with maximum funding rate [%]
G10: Funding rate	Actual/effective funding rate by funding regime [%]
G11: Frequency of maximum funding	Number/share of approvals with maximum funding amount [%]
(A) - Target achievement: To what degree have the established targets been achieved?	
A1: Reduction in final energy consumption	Reduction of fuel and electricity consumption [MWh_{fin}]
A2: Reduction in primary energy consumption	Reduction of fuel, electricity and resource consumption [MWh_{pri}]
A3: Reduction in GHG-emissions	GHG-emission savings by reduction of fuel, electricity and resource consumption [t CO_2-eq.]
A4: Reduction in energy and resource costs	Energy and resource cost savings by reduction of fuel, electricity and resource consumption [Euro]
A5: Time of target achievement	Are the internal programme objectives achieved in the modules?
(B) - Effectiveness: To what degree is the measure causal to the achievements?	
B1: Total value of the effect adjustment	Value of free-rider, pull-forward, follow-on and spill-over effects
(C) - Economic efficiency: How efficient is the measure from the implementer’s perspective with regard to achieving the targets and concerning the use of resources?	
C1: Total costs (funding and admin. costs)	Funding by funding regime and administrative costs [Euro]
C2: Funding efficiency	Funding efficiency relative to final energy/primary energy/GHG-emission reduction [Euro/$MWh_{fin/prim}$ and Euro/t CO_2-eq.]
C3: Relative administrative costs	Administrative costs per final energy/primary energy/GHG emission-savings [Euro/$MWh_{fin/prim}$ and Euro/t CO_2-eq.] and per application/approval
C4: Total triggered investments	Triggered investments by funding regime [Euro]
C5: Leverage effect	Ratio: Triggered investments to amount of funding [Euro/Euro]
(D) - Procedural implementation: How is the operational implementation perceived?	
D1: Process from company perspective	Qualitative: User satisfaction with the implementation
D2: Process from implementer's perspective	Qualitative: Implementers satisfaction with the implementation
D3: Response time	Average response time per application/approval/rejection [days]
D4: Complaints management	Number of complaints, Average complaint processing time [days]
(E) - Specific knowledge interest: Module-specific questions that go beyond the specified evaluation objectives	

Source: Neusel, Hirzel, Weinert, et al. (2024)

Table 6. Selected KPIs for categories G, A and C at module level and for the overall programme over time

	2019	2020	2021	2022	2023
(G) Number of applications / Number of approvals					
Module 1	7,198/ 6,067	8,864/ 7,165	9,582/ 8,870	9,413/ 6,868	5,740/ 6,724
Module 2	119/ 54	193/ 146	281/ 145	364/ 162	281/ 268
Module 3	340/ 233	620/ 452	865/ 619	919/ 945	981/ 839
Module 4	1,396/ 595	2,766/ 2,116	4,757/ 3,316	5,894/ 3,714	5,815/ 5,451
Module 5	-	-	-	-	819/ 175*
Module 6	-	-	-	-	392/ 251
Competition	64/ 26	86/ 39	43/ 27	61/ 24	102/ 51
Modules 1-6	9,053/ 6,949	12,443/ 9,879	15,485/ 12,950	16,590/ 11,689	14,028/ 13,708
Overall programme	9,117/ 6,975	12,529/ 9,918	15,528/ 12,977	16,651/ 11,713	14,130/ 13,759
(G) Number of approvals by funding line (grant/ credit/ competition)					
Module 1	6,056/ 11/ -	7,147/ 18/ -	8,854/ 16/ -	6,864/ 4/ -	6,724/ 0/ -
Module 2	45/ 9/ -	126/ 20/ -	130/ 15/ -	147/ 15/ -	256/ 12/ -
Module 3	233/ -/ -	452/ -/ -	616/ 3/ -	943/ 2/ -	839/ 0/ -
Module 4	365/ 230/ -	1,641/ 475/ -	3,077/ 239/ -	3,600/ 114/ -	5,388/ 63/ -
Module 5	-	-	-	-	175*/ -/ -
Module 6	-	-	-	-	246/ 5/ -
Competition	-/ - / 26	-/ - / 39	-/ - / 27	-/ - / 24	-/ - / 51
Modules 1-6	6,699/ 250/ -	9,366/ 513/ -	12,677/ 273 -	11,554/ 135/ -	13,628/ 80/ -
Overall programme	6,699/ 250/ 26	9,366/ 513/ 39	12,677/ 273/ 27	11,554/ 135/ 24	13,628/ 80/ 51
(C) Approved funding/ Triggered investments in Mio. Euro					
Module 1	49.9/ 157.5	56.3/ 180.2	75.7/ 244.1	70.2/ 215.3	83.4/ 248.3
Module 2	10.1/ 18.9	57.2/ 115.9	106.6/ 217.6	135.6/ 279.5	363.0/ 765.4
Module 3	5.0/ 15.8	15.0/ 47.5	18.9/ 59.9	40.7/ 123.5	41.6/ 126.1
Module 4	50.6/ 299.4	181.9/ 874.0	336.6/ 1,463.7	310.0/ 1,338.5	608.9/ 2,377.6
Module 5	-	-	-	-	6.5/ -
Module 6	-	-	-	-	5.3/ 15.7
Competition	14.1/ 31.8	43.5/ 93.1	23.7/ 52.9	81.7/ 148.4	87.2/ 180.1
Modules 1-6	115.6/ 491.5	310.3/ 1,217.5	537.7/ 1,985.3	556.5/ 1,956.9	1,108.7/ 2,628.8
Overall programme	129.7/ 523.3	353.8/ 1,310.7	561.4/ 2,038.2	638.2/ 2,105.3	1,195.9/ 3,713.3
(C) Administrative costs in Mio. euro					
Overall programme	5.4	5.8	6.9	7.3	11.0
(A) Estimated reduction in GHG-emission equivalents in kt CO_2-eq./a (gross/ net)					
Module 1	61/ 43	63/ 44	99/ 72	93/ 66	58/ 43
Module 2	14/ 12	89/ 92	16/ 16	200/ 200	400/ 412
Module 3	6/ 5	13/ 9	16/ 12	25/ 20	21/ 16
Module 4	677/ 546	519/ 419	1,016/ 835	974/ 783	1,363/ 1,138
Module 6	-	-	-	-	1/ 1
Competition	60/ 56	187/ 165	103/ 103	661/ 677	284/ 262
Modules 1-4 & 6	758/ 606	684/ 564	1,147/ 935	1,292/ 1,069	1,844/ 1,611
Overall programme	818/ 662	871/729	1,250/ 1,038	1,953/1,746	2,128/ 1,872
(A) Estimated reduction in energy and resource costs in Mio. euro/a* (gross/ net)					
Module 1	17.3/ 12.0	18.9/ 13.3	39.5/ 28.8	47.7/ 33.8	30.7/ 22.4
Module 2	-0.05/ -0.04	-0.7/ -0.7	-2.2/ -2.2	0.4/ 0.4	-1.9/ -2.0
Module 3	2.0/ 1.5	5.5/ 3.9	5.1/ 3.8	14.1/ 11.3	11.3/ 8.8
Module 4	299.1/ 241.3	142.5/ 114.9	238.7/ 196.2	296.6/ 238.4	600.9/ 501.7
Module 6	-	-	-	-	0.2/ 0.2
Competition	11.1/ 10.4	22.1/ 19.4	-3.3/ -3.3	51.0/ 52.2	-26.9/ -24.8
Modules 1-4 & 6	318.2/ 254.9	166.2/ 131.4	281.1/ 226.6	358.8/ 283.9	641.2/ 531.1
Overall programme	329.4/ 265.3	188.8/ 151.3	279.9/ 225.5	409.8/ 336.1	614.2/ 506.4

(C) GHG-funding efficiency in euro/t CO_2-eq. (gross / net) *(funding incl. administrative costs in relation to GHG-savings over lifetime)*					
Module 1	103/ 135	113/ 147	97/ 123	96/ 124	180/ 228
Module 2	95/ 104	81/ 78	849/ 847	85/ 85	113/ 110
Module 3	167/ 204	231/ 297	241/ 302	326/ 393	399/ 488
Module 4	10/ 12	45/ 53	42/ 49	40/ 48	56/ 66
Module 6	-	-	-	-	569/ 611
Competition	31/ 34	30/ 33	29/ 30	16/ 15	39/ 42
Modules 1-4 & 6	20/ 24	58/ 68	60/ 71	55/ 64	76/ 85
Overall programme	21/ 25	52/ 60	57/ 67	42/ 46	71/ 79

*For Module 5, the value refers to completed transformation plans (instead of approvals)

Source: Own compilation based on Neusel, Hirzel, Heinrich, et al. (2024)