

Efficiency unleashed: evolution and impact of Germany's funding scheme for energy and resource efficiency in the economy

Lisa Neusel & Simon Hirzel
Fraunhofer Institute for Systems and Innovation Research ISI
Breslauer Strasse 48
76139 Karlsruhe
Germany
lisa.neusel@isi.fraunhofer.de, simon.hirzel@isi.fraunhofer.de

Karsten Weinert, Stephan Heinrich
& Anna-Maria Grodeke
Prognos AG
Goethestrasse 85
10623 Berlin
Germany

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Abstract

The Federal Funding Scheme for Energy and Resource Efficiency in the Economy (EEE) is the central public funding programme for addressing energy efficiency and reducing greenhouse gas emissions in German companies. In 2023, it exceeded a funding volume of 1 billion euros for the first time. The multi-measure scheme consists of several modules. In its original setup, it covered support for investments 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 and later also resource optimizations of plants and processes. Recently, two new modules have been added, focusing on 5) transformation concepts and 6) electrification in micro and small enterprises. On the one hand, the paper aims to examine key performance indicators from the four evaluation rounds since 2019 in order to review the target achievement, effectiveness and economic efficiency of the EEE's measures. Overall, the programme as a whole has achieved gross GHG emissions savings of a good 4.8 million tonnes of CO₂ since its introduction until the end of 2022. On the other hand, the paper illustrates the evolution of the EEE over the last five years in order to derive exemplary implications for the evaluation of (other) dynamic funding schemes. The results suggest, among other things, that it is important to distinguish major structural breaks, such as changes in funding directives dur-

ing the year or new funding objects, at an early stage in order to prepare for them in an ongoing evaluation. Consequently, it is advisable for policy-makers to be aware that a redesign of a funding programme may also have substantial repercussions on its evaluation.

Introduction

In recent years, reporting requirements on measures to achieve EU-wide and national targets for energy efficiency and climate targets have increased considerably in recent years at both the European and national level. On the EU-level the most detailed are the latest requirements for the communication of measures and methods for the implementation of Article 8 of the Energy Efficiency Directive recast (Directive 2023/1791/EU, Annex V). Germany's energy and climate targets, with the overall goal of achieving GHG neutrality in 2045, are legally defined in the revised Federal Climate Change Act (KSG) of 2021 and the Energy Efficiency Act (EnEfG) of 2023. Both provide for reporting requirements in several places, which also include the evaluation of measures.

Publicly funded policy measures are an important cornerstone to improve energy efficiency. Since they use public money, ex-post evaluations are regularly required to review their efficiency and effectiveness. In addition, the climate targets require a continuous monitoring of the impact of policies and funding programmes. Ex-post evaluations make an important contribution to this. Such evaluations may also help to estimate the costs and impact of future measures in ex-ante evaluations (Brunzema et al. 2022), to understand the performance of measures as compared to others (e.g. Andrei et al. 2021) and to

adapt such measures to other locations and different circumstances (e.g. Tanaka 2011).

Economidou et al. 2022 stress the importance for a coherent reporting framework for policies and measures and harmonised reporting approaches. In this regard, key performance indicators are a common element in (ex-post) evaluations, not only for analysing the efficiency and effectiveness of measures, but also as a reference for comparisons between different measures, even if they are subject to limitations (Hirzel and Schlomann 2022). Examples of ex-post side-by-side presentations include i) the works by Fleiter et al. 2012 who analyse the German energy audit programme whilst also setting up a comparative table with similar programmes in the USA, Austria and Sweden or ii) the analysis by Patel et al. 2021 who compare energy efficiency programmes from Switzerland and the USA. This is particularly important when aggregating results for multi-measure schemes with varying technologies and target groups.

A central multi-measure scheme in Germany is the Federal Funding Scheme for Energy and Resource Efficiency in the Economy (EEE). It came into force in 2019 as a successor to the German Energy Efficiency Fund (Voswinkel 2018). Previous works on the Fund dealt with methodological aspects related to establishing a harmonized framework, which was later adapted and expanded for the evaluation of the EEE (Hirzel and Schlomann 2022) (Table 1). What has been missing so far is an overview of the EEE's performance indicators, as presented in this contribution. The aim of this is to assess the EEE's impact with regard to the reporting obligations. In addition, the dynamic character of the EEE, reflected in the various amendments in recent years, poses methodological and operational challenges for the ongoing evaluation. The analysis of these can help to prepare future evaluations of (other) rapidly evolving multi-measure programmes. Therefore, this contribution focuses on the underlying research questions:

- What is the overall impact of the German EEE from the four rounds of evaluation of 2019 to 2022?
- What are the implications for evaluation of fast evolving multi-measure schemes such as the EEE?

To answer these questions, a brief introduction to the EEE's evolution and its evaluation methodology are provided first. Thereafter, the results from applying this methodology to the EEE are discussed, covering several aggregated quantitative key performance indicators. Finally, a discussion of issues related to the evaluation of fast evolving multi-measure schemes such as the EEE follows before the conclusions.

The German EEE Funding Scheme

ORIGINAL SETUP OF THE EEE

As multi-measure funding scheme, the EEE consists of several **modules** (Figure 1). In its original setup, it covered support for investments in 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. Depending on the module, the EEE offers three modes of funding: a **grant**-based line that offers direct investment grants, a **credit**-based line that offers low-interest loans with a repayment subsidy and a **competition**-based line. While Modules 1 to 3 offer funding for specific technologies, Module 4 is technology-open and requires an individual energy-saving concept. In contrast to Modules 1 to 3, eligible investments are specified according to funding topics and not according to specific technologies in Module 4. Furthermore, there is also a competitive funding line with similar conditions as in Module 4. However, in this competitive line, market-based elements are introduced where submissions are ranked according to their funding efficiency and only the most competitive offers obtain funding in the form of a grant. The general **target groups** of all three lines are identical and focus on private-sector companies (SMEs and large companies) with premises located in Germany as well as municipal companies, freelancers (conditional) and contractors representing a company. Thus, as multi-measure scheme, the EEE allows to meet the diverse needs and projects with different degrees of complexity.

The different modules are operated by different **implementing agencies**: The Federal Office of Economic Affairs and Export Control BAFA offers grants, the German development bank KfW offers credits and the funding competition as well as Module 5 are administered by VDI/VDE-IT as an implementing agency. For further information on the general funding mechanisms and an analysis of the advantages and disadvantages of market-based and classical funding instruments on the example of the EEE the reader is referred to Brunzema et al. 2022 and Hirzel et al..

THE EEE'S EVOLUTION SINCE 2019

To understand the challenges that the continuous evolution of the EEE poses for the annual evaluation, a closer look at its dynamics is necessary. The **legal basis** for the classical grant and credit line (Modules 1 to 6) and the competitive line (equivalent of Module 4) are codified in separate, but similar **funding**

Table 1. 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 analyses 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 et al. 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

Cross-cutting technologies		Process heat from renewable energies		I&C, sensors and energy management software		Optimization of plants and processes		Transformations concepts	Electrification in micro and small enterprises	
Module 1		Module 2		Module 3		Module 4		Module 5	Module 6	
Grant (BAFA)	Credit (KfW)	Grant (BAFA)	Credit (KfW)	Grant (BAFA)	Credit (KfW)	Grant (BAFA)	Credit (KfW)	Grant (VDI/VDE-IT)	Grant (BAFA)	Credit (KfW)
Promotion of investments to increase the energy efficiency through highly efficient and commercially available technologies for industrial and commercial applications.		Promotion of systems for the provision of heat from solar collectors, heat pumps, geothermal systems or biomass systems where >50% of the heat is used for processes.		Promotion of software and hardware for enhancing and using energy or environmental management systems.		Technology-neutral promotion of investments in energy- and resource-oriented optimization of industrial and commercial plants and processes and the use of heat from renewables and waste heat.		Promotion of transformation concepts to support the planning and implementation of a decarbonization strategy and the transformation towards climate neutrality.	Promotion of the replacement/conversion of existing production plants that are powered by fossil fuels with new plants that are powered by electricity or renewable energies.	

Figure 1. Overview of the EEE and its funding modules.

directives. Both directives were updated several times to refine and update the funding scheme. The first directive for the competitive line came into force approximately three months later than the classical line, i.e. the competitive line was not available throughout the entire year 2019 as opposed to the classical line.

Figure 2 provides an overview of the changes, based on the amendments made to the original directives from 2018 to 2023. The changes to the EEE can be discussed along six categories: the frequency of revisions, the scheme's name, its quantitative targets, its funding modules, the maximum funding and the funding rates. Furthermore, a distinction is made between the grant/credit-lines and the competition-based approach.

- The chronological development already shows that the **frequency of revisions** has tended to increase compared to the early years, with only 5 months separating the latest revisions. It should be noted, that the directives generally come into force during the course of the year, i.e. changes may occur during the year. The latest revision came into force on 15 February 2024¹. While these directives provide the legal basis for the implementation, operational details set out in additional module-specific guidelines issued by the implementing agencies, including chronicles of changes to make it easier for funding recipients to keep track. These range from adapting the funding criteria to the directive and clarifying the measures that are not eligible for funding to specifying the requirements for the technologies to be funded.
- A substantial change was the expansion of the EEE to include **resource efficiency** in November 2021. This was also reflected in the modified **name of the programme**. It entails that investments in measures not only leading to energy-related CO₂ savings but also to a reduction in resource requirements and thus to CO₂ savings are now also eligible for funding, e.g. resource-optimised process management or the avoidance of production waste. For this, a comprehensive list of CO₂ factors for various resources (e.g. raw materials, materials, preliminary products) was made available to funding recipients to determine related potential savings (BAFA 2024).

- An addition of new modules and revised funding criteria also led to several adjustments of the **quantitative targets** of the EEE as defined in the directives. Intermediate evaluation results were also incorporated into the (ex-ante) assessment of these new targets. While the targets (in terms of realized measures, GHG and final energy reduction) in the original directives were set for the time horizon up to the end of 2023, the revision in November 2021 did not extend the target period, but set revised targets for the period between 2022 and 2026.
- In terms of **funding modules**, a new Module 5 'Transformation concepts' was introduced in November 2021 to support companies in planning their decarbonisation strategy. With a new Module 6 in May 2023, an additional focus was placed on the 'Electrification of micro and small enterprises' (also see Figure 1). This includes the replacement of existing fossil-powered installations with new electrically powered ones or a conversion to electricity. Next to this, there are changes to existing modules. They include the addition of new funding objects, such as the funding for the development and utilisation of deep geothermal energy in Module 2 (since May 2023), or changes to the specifications of existing funding object set in the operational guidelines. In particular, the efficiency criteria for funded technologies (e.g. for high efficiency compressed air generators) and their revisions are also assessed within the evaluation. In addition, the previous CO₂ factors for electrical energy have steadily been revised.
- Funding is provided in the grant and credit line in accordance with either the EU's de minimis aid or its General Block Exemption Regulation (GBER). These restrictions do not apply in the funding competition. Within this regulatory framework, there has been an increase over the past few years in the **maximum permitted funding amount** per application in Modules 2 to 4 (under GBER) and the funding competition. In the funding competition in particular, the current funding maximum of 15 million euros² that was originally set to 5 million euros enables even larger and more complex projects.

1. Please note: the latest directive dated 15 February 2024 is not part of this publication

2. Increased to 20 million euros as part of the latest directive dated 15 February 2024, which is not part of this publication.

- Figure 2 also illustrates the high level of dynamism and diversity across the modules in terms of the respective funding amounts and **funding rates**. In general, the last revision optimised the funding opportunities for SMEs in particular: Originally, all SMEs received a general additional bonus of 10 percentage points. From May 2023 on, a distinction of small and medium-sized enterprises when determining the amount of funding was introduced: small companies can now receive additional 10 percentage points. In Module 4, there is a double ceiling for funding, which was recently increased again for small companies in May 2023. Thus, for small companies, there is a first ceiling by limiting the funding to 50 % of eligible costs. A second ceiling is a funding rate of 1,200 Euros per annually saved tonne of carbon dioxide emissions (i.e. if the funding rate were to be higher, it would be cut to this ceiling). In the competitive line, the values can recently be up to 60 % of the eligible costs in case of successful participation.

While some of these revisions are only of minor relevance to the evaluation, others have a substantial impact on it, as discussed below.

Evaluation methodology

The results in this paper originate from the ex-post evaluation of the EEE (Neusel et al. 2023). The current evaluation is carried out annually along a common framework (Schlomann et al. 2020). Key performance indicators are part of this framework.

Table 2 therefore provides an overview of these **key performance indicators** (KPIs) chosen for the EEE evaluation on the level of individual measures. Based on the indicators of the predecessor (Hirzel and Schlomann 2022), their overall structure has been supplemented and expanded for the EEE. They are structured along the established core evaluation areas, i.e. indicators for reviewing target achievement (A), effectiveness (B) and economic efficiency (C). The indicators of category B are also included as net values in the analyses of categories A and C. In addition, a group of new indicators of general knowledge interest (G) has been added. Further additional indicators cover the perception of the procedural implementation (D). A category of indicators on specific knowledge interest (E) supplements the general indicators of category G and is not listed in detail in Table 2. These relate, for example, only to certain modules and serve knowledge interests that go beyond the evaluation core objectives (e.g. door-opener effect: “effect of modules 1–3 as a door opener for module 4 or competition”). Most indicators are presented as quantitative values (e.g. GHG savings in tonnes of CO₂-eq.), yet some are provided on a qualitative scale (e.g. course of the process from the perspective of the funding recipients).

The KPIs are 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 until 2022. 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. To complement data from administrative sources, a **survey** among participants has been implemented as an online survey among those participants who received a positive response to their application. It consists of various common questions across all lines and specific questions addressing particular aspects related of the individual modules or implementing agencies.

While many indicators are based on common determination methods, the quantification of savings differs by module. For some, especially Module 4 and the funding competition, information on the achieved savings is directly available from the applications. To this end, applicants are provided with a list of emission factors to calculate their targeted CO₂ savings. For others, data from the application database and/or information from the survey, e.g. about technologies, operating hours, expected savings, are used. For further details on the overall methodology and methodological challenges, the reader is referred to Schlomann et al. 2017; Voswinkel 2018, 2019, 2020 and Hirzel and Schlomann 2022.

Results and discussion

QUANTIFIED IMPACT FROM THE EVALUATION

The aggregation of the overall results, as shown in Table 3, can be pointed out along the first research question of this paper: *What is the overall impact of the German EEE from the four rounds of evaluation of 2019 to 2022?*

The focus is on a limited selection of indicators for the previously introduced indicator categories G, A and C. The results are usually presented by either the overall programme or the relevant modules and/or funding lines. No results are shown yet for Module 5 and Module 6, as a detailed evaluation has not yet been carried out.

Since the introduction of the EEE in 2019, the **number of funding applications** received for the overall programme, i.e. grant and credit line as well as competitive line, has risen steadily. This shows that the programme has been able to continue and expand its successful start in subsequent years and that it has been very well received by funding recipients. Module 1 has received most applications in terms of numbers since the start of the programme (2022: 57 %), while its share of funding in terms of money is substantially lower in proportion (2022: 11 %). Module 4 is the largest one in terms of funding since the start (2022: 49 %, with only 35 % of applications). These structural differences can be explained by larger projects in Module 4 (and the competitive line) where the technology-openness allows for applications that are more comprehensive as compared to Module 1.

The total number of applications submitted in the funding package between 2019 and 2022 resulted in 41,583 funding commitments, i.e. **approved applications**. The target of 54,000 realised measures from 2022 to 2026 set in the directive of November 2021 (see Figure 2) will probably be exceeded if approvals from 2022 will remain unchanged. However, the steady increase in the number of applications is only partially reflected by the number of actual funding approvals; in 2022 in particular, a decline was recorded for the first time. The main reason for this is a backlog in the processing of ap-

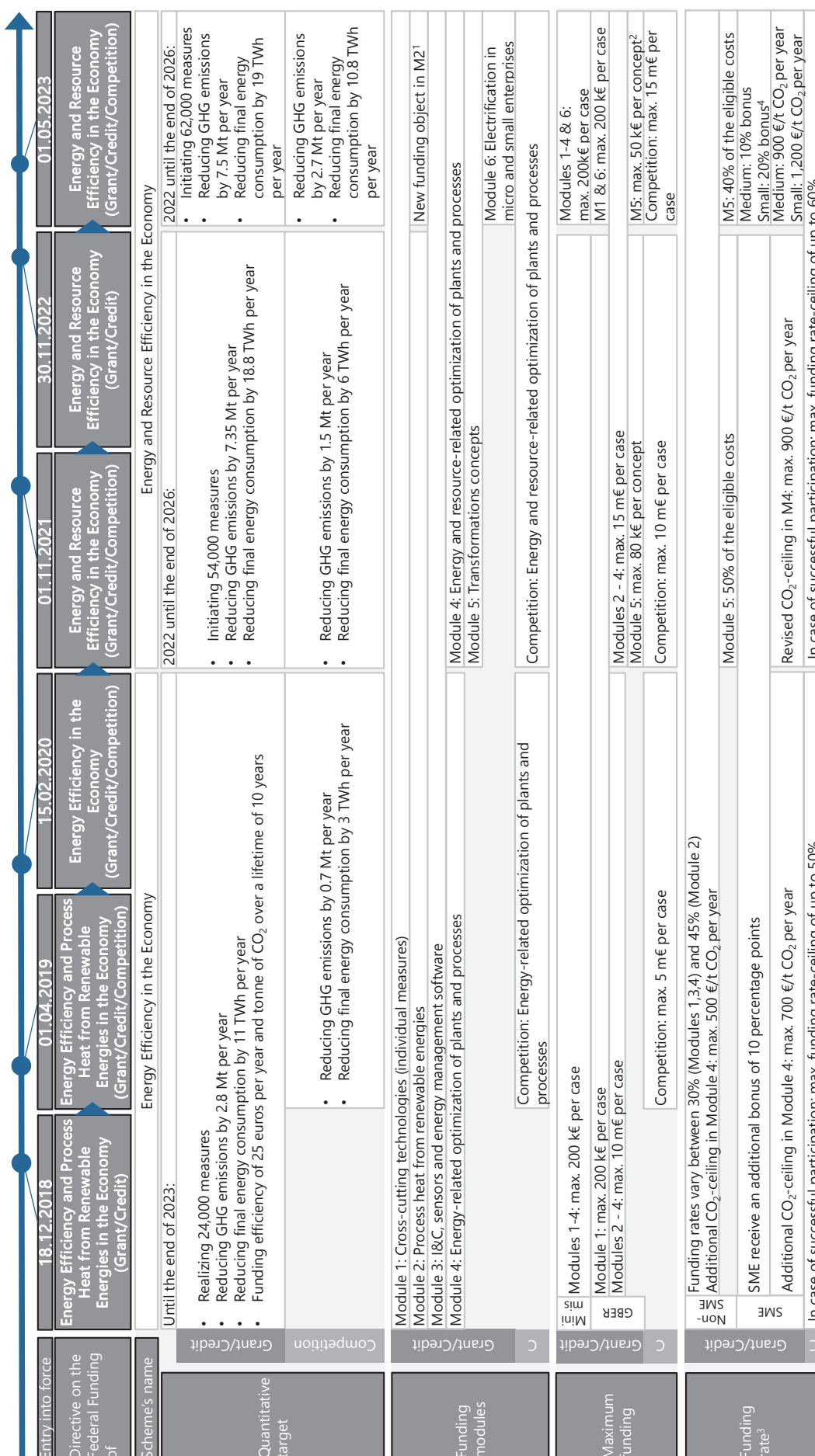


Figure 2. Evolution of the EEE between 2018 and 2023.

¹ Funding for the development and utilization of deep geothermal energy² For companies that are active members of a network of the Initiative Energy Efficiency and Climate Action Networks (IEEKN); max. 80 k€³ under De-minimis in relation to eligible investment costs, under GBER in relation to eligible additional investment or investment costs (depending on GBER article)⁴ Except funding in Module 6 (only small companies); 10% (GBER) or 33% (de minimis)

plications by the implementing agencies, particularly in Module 1.

There are clear **differences in the availment of the various funding lines**. Overall, Table 3 shows that the demand for the credit line is substantially lower across Modules 1 to 4. Accompanying survey results suggest that the grant line is more accessible for potential recipients. One reason could be the requirement of an additional intermediary, i.e. a house bank, in the credit line. Another possible explanation is the change in the framework conditions, in particular the interest rate environment. When considering whether all funding lines should be maintained in the future, it should be borne in mind that the costs of setting up and maintaining the infrastructure for application review in the implementing agencies have already been incurred.

A total of almost 1.7 billion euros in **funding** was approved from 2019, 2020, 2021 and 2022 across the overall programme. The funding approvals in the period from 2019 to 2022 triggered **investments** totalling 6.0 billion euros. Since the start of the EEE in 2019, **administrative costs totalling** 25.4 million euros were incurred up to the end of 2022. The costs incurred per year have been in the same order of magnitude over the years, with a slight upward trend. Looking at the administrative costs relative to the applications, these fell on average between 2019 and 2022 (gross per application from 589 to 441 Euros). This can be seen as evidence of learning and economies of scale at the implementing agencies due to the increased number of funding cases (initialisation costs are spread over more applications) and the processing routine gained in the process. The strong heterogeneity between the modules and funding lines should be noted.

Table 2. Overview of key performance indicators for 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 _{prim}]
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	

Table 3. Aggregated key performance indicators on the EEE's impact.

	2019	2020	2021	2022
(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
Module 2**	119/ 54	193/ 146	281/ 145	364/ 162
Module 3	340/ 233	620/ 452	865/ 619	919/ 945
Module 4	1,396/ 595	2,766/ 2,116	4,757/ 3,316	5,894/ 3,714
Competition	64/ 26	86/ 39	43/ 27	61/ 24
Modules 1-4	9,053/ 6,949	12,443/ 9,879	15,485/ 12,950	16,590/ 11,689
Overall programme	9,117/ 6,975	12,529/ 9,918	15,528/ 12,977	16,651/ 11,713
(G) Number of approvals by funding line (grant/ credit/ competition)				
Module 1	6,056/ 11/ -	7,147/ 18/ -	8,854/ 16/ -	6,864/ 4/ -
Module 2**	45/ 9/ -	126/ 20/ -	130/ 15/ -	147/ 15/ -
Module 3	233/ -/ -	452/ -/ -	616/ 3/ -	943/ 2/ -
Module 4	365/ 230/ -	1,641/ 475/ -	3,077/ 239/ -	3,600/ 114/ -
Competition	-/ -/ 26	-/ -/ 39	-/ -/ 27	-/ -/ 24
Modules 1-4	6,699/ 250/ -	9,366/ 513/ -	12,677/ 273/ -	11,554/ 135/ -
Overall programme	6,699/ 250/ 26	9,366/ 513/ 39	12,677/ 273/ 27	11,554/ 135/ 24
(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
Module 2**	10.1/ 18.9	57.2/ 115.9	106.6/ 217.6	135.6/ 279.5
Module 3	5.0/ 15.8	15.0/ 47.5	18.9/ 59.9	40.7/ 123.5
Module 4	50.6/ 299.4	181.9/ 874.0	336.6/ 1,463.7	310.0/ 1,338.5
Competition	14.1/ 31.8	43.5/ 93.1	23.7/ 52.9	81.7/ 148.4
Modules 1-4	115.6/ 491.5	310.3/ 1,217.5	537.7/ 1,985.3	556.5/ 1,956.9
Overall programme	129.7/ 523.3	353.8/ 1,310.7	561.4/ 2,038.2	638.2/ 2,105.3
(C) Administrative costs in Mio. euro				
Overall programme	5.4	5.8	6.9	7.3
(A) Estimated reduction in GHG-emission equivalents in kt CO₂-eq./a* (gross values/net values)				
Module 1	61/ 43	63/ 44	99/ 72	93/ 66
Module 2**	8/ 7	21/ 22	16/ 16	200/ 200
Module 3	6/ 5	13/ 9	16/ 12	25/ 20
Module 4	677/ 546	519/ 419	1,016/ 835	974/ 783
Competition	60/ 56	187/ 265	103/ 103	661/ 677
Modules 1-4	753/ 601	616/ 494	1,147/ 935	1,292/ 1,069
Overall programme	813/ 657	803/ 659	1,250/ 1,038	1,953/ 1,746
(A) Estimated reduction in energy and resource costs in Mio. euro/a*				
Module 1	17.3	18.9	39.5	47.7
Module 2**	-0.008	-0.2	-0.03	0.4
Module 3	2.0	5.5	5.1	14.1
Module 4	299.1	142.5	238.7	296.6
Competition	11.1	22.1	-3.3	51.0
Modules 1-4	318.3	166.7	283.2	358.8
Overall programme	329.4	188.8	279.9	409.8
(C) GHG-funding efficiency in euro/t CO₂-eq.* (funding incl. administrative costs in relation to GHG-savings over lifetime)				
Module 1	103	113	97	96
Module 2**	161	347	854	85
Module 3	167	231	241	326
Module 4	10	45	42	40
Modules 1-4	20	64	60	55
Overall programme	21	56	57	42

* Including savings triggered by resource efficiency

** In Module 2, an individual case review was carried out for the first time in 2022 with the aim of more accurately mapping the savings and thus the funding efficiency. This essentially explains the significant improvement in funding efficiency in 2022. The value for 2022 is therefore not directly comparable with previous years. It can be assumed that the values determined for the previous years 2019, 2020 and 2021 are underestimated. A detailed review of the previous year's figures at individual case level will be carried out as part of the 2023 evaluation

With regard to **target achievement (A)** Table 3 focuses on the new annual GHG-savings achieved for the evaluation years 2019 to 2022 and the resulting savings in energy and resource costs. The indicators of category B (effectiveness), the so-called effect adjustment, are shown in table indirectly, i.e. the values for target achievement are distinguished into gross and net values on the example of GHG-savings. The (net) savings for which the funding is actually responsible are determined by adjusting the gross values for effects. This takes into account free-rider, pull-forward, follow-on and spill-over effects at the level of the individual modules. Across the entire funding scheme, the effect adjustment reduces the gross savings by around 17 %. This is similar to the value of its predecessor the German Energy Efficiency Fund.

The **GHG reductions achieved** in the EEE are based on estimated energy savings (differentiated by electricity and fuels) or the alternative generation of process heat from renewable energies. Since the introduction of resource efficiency in November 2021, GHG savings from resource savings are included, as well. In absolute terms, Module 4 dominates the savings in all years. Particularly noteworthy in the competitive line is the share added in 2022 through resource efficiency, which accounts for slightly more than half of the total savings in the competitive line and is strongly dominated by one funding case. When assessing target achievement as part of the evaluation, the changes in the targets of the respective directives must be taken into account (see Figure 2). In total, the overall programme has achieved gross savings in GHG emissions (including resource efficiency) of a good 4.8 million tonnes of CO₂-eq. since it came into force until the end of 2022 (see Figure 3). This means that the GHG reduction target defined in the original funding directive of a total of 3.5 million tonnes of CO₂-eq. by the end of 2023 (of which 2.8 million tonnes from grant/credit and 1.5 million tonnes from competition) has already been achieved ahead of schedule. Figure 3 illustrates the break in the target with the entry into force of the amended directive on November 2021. The GHG reduction target of 8.85 million tonnes of gross CO₂-eq. defined there now applies for the period 2022 to 2026 (of which 7.35 million tonnes from grant/credit and 1.5 million tonnes from competition). Assuming that the level

of 2022 continues, it would probably be achieved or slightly exceeded. It should be noted that the funding competition would reach its target in the projection ahead of schedule in 2024, particularly due to the resource savings added in 2022. The grant and credit line remains significantly below the target value in the extrapolation and would only reach it later, in August 2027.

The **energy and resource cost savings** can be derived from the savings. For example, the measures subsidised in 2022 will save a total of around 1.2 billion euros gross in energy and resource costs. Compared to the stable prices of previous years, there was a significant price increase in 2022 for electricity and especially for fuels because of the energy crisis, which is reflected in the energy cost reduction indicator.

The central indicator of the **economic efficiency control (C)** is the **GHG funding efficiency**. In line with the methodology guideline (Schlommann et al. 2020), this is defined as: “Ratio between the resources used (funding including administrative costs) and the GHG emission reduction determined over the lifetime”. The wide variation in funding efficiency between the modules is largely due to the differences in the types of funding. Compared to the first year under review, 2019, there was already a deterioration in the lifetime-related GHG funding efficiency in 2020 for all modules with the exception of the funding competition. From 2020, this indicator then stabilised across the entire package and most modules. One consequence of the deterioration in funding efficiency observed between 2019 and 2020 was that the funding efficiency target of 25 Euros per tonne of CO₂-eq. for the overall programme as set in the original directive (or 24 Euros per tonne of CO₂-eq. according to the directive as of November 2021) was only achieved in 2019 alone. In subsequent years, however, this target value is missed by a wide margin (see Table 3).

EVALUATION OF DYNAMIC FUNDING SCHEMES: ISSUES TO CONSIDER

Based on the evolution of the EEE described, five issues can be derived addressing the second research question: *What are the implications for evaluation of fast evolving multi-measure schemes such as the EEE?*

The focus lies on which additional **questions or tasks** that arise from the previously mentioned changes and what im-

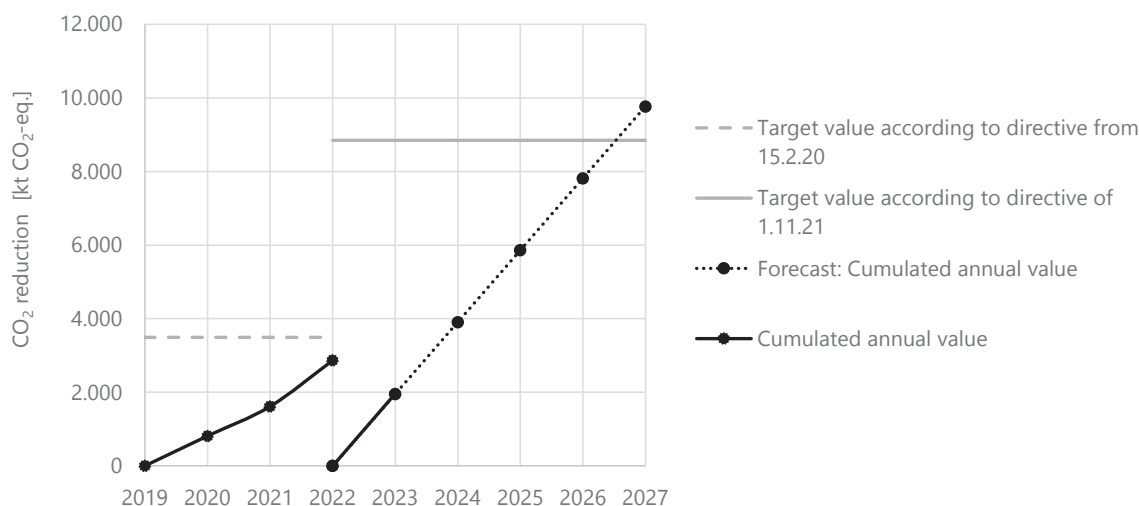


Figure 3. Target achievement of the EEE in terms of GHG savings (based on the four rounds of evaluation).

plications this might have on the evaluation. The aim of this analysis is to contribute to preparing future evaluations of (other) rapidly evolving multi-measure programmes for potential changes.

Issue #1: Frequency of revision

Firstly, cuts during the year must be mentioned here for the directives to be considered in the corresponding evaluation year. One question is how to bring together the different directives in one evaluation year. An implication of organisational nature is on how data collection and processing is organized. In other terms, depending on the extent of the modifications, a differentiation by application date (application according to old or new directive in the corresponding year) may be required. There is often a time lag between application and approval, so that even after a new directive comes into force, approvals are still being granted under the old directive. This may have a substantial implication on the evaluation effort since data collection and processing must be performed for two setups and merged. However, it should also be noted that it takes time for changes to take effect, i.e. a modification of the funding setup late in the year may not entail an actual need for change in data collection and processing, since applications according to the new setup will only enter into effect with some delay. Another implication in terms of content may also be that target periods change and the assessment of target achievement in the evaluation must be adjusted accordingly (see Issue #3).

Secondly, experience from the EEE shows that the high frequency of revisions can lead to a processing backlog at the implementing agencies. This has an impact on the number of approvals in the evaluation year concerned and must be taken into account when assessing programme performance as part of an annual evaluation and comparison.

Thirdly, it can be stated that the implementation of the procedures at the implementing agencies may take some time after a directive revision comes into force. From an operational perspective, this can imply delays in the provision of databases for the evaluation, which must be taken into account.

Issue #2: Resource efficiency

A major change was the expansion of the EEE to include resource efficiency. A resulting task was to revise the set of KPIs and to integrate additional ones in the existing evaluation framework (mainly category A). This was done by adding indicators for resource savings in terms of CO₂, primary energy and avoided resource costs. Although the saving of resources does not affect the final energy consumption, it is reflected in the CO₂ savings achieved. On the basis of databases on the cumulative energy consumption of various resources, primary energy factors and thus primary energy savings could also be assigned to the resources. As a result, the transparency of what is included in the respective indicators has become more and more important. This is also due to the fact that combined energy and resource projects can also occur.

Issue #3: Revised quantitative targets

As already shown in Figure 2, there may be changes to the quantitative targets and the respective target period due to new funding objects or revised funding criteria and an extended period of validity of the directive. This affects how target achieve-

ment is monitored as part of the evaluation while ensuring the different target achievements are clearly distinguished. An extension of the directive's validity may also have implications for the administrative costs incurred for setting up and implementing the programme. A methodological question concerns whether initialisation costs, e.g. for setting up the IT infrastructure and hiring and training employees, are allocated to the first evaluation year, which limits comparability with subsequent years, or whether they should be distributed evenly over the period of the directive. Implementation costs, on the other hand, are incurred annually due to the processing of applications. If initialisation costs are substantial and are distributed across the years, an extension of validity triggers the question how to best avoid breaks in the reported and how to (re-)attribute (remaining) costs.

Issue #4: Revised funding modules

Newly added funding modules or funding objects always require an extension of the evaluation. From an organisational point of view, this implies that evaluation scripts need to be expanded, while surveys, for example, need to be supplemented in terms of content. But extensions are also necessary from a methodological perspective: For example, for the newly added Module 6 in the EEE, which, unlike Modules 1 to 3, is designed to be technology-wise fairly open, but in comparison to Module 4, which is also technology-open, does not contain any information on savings from the subsidised technologies in the funding database. The development of a suitable savings calculation logic is particularly relevant if savings are only achieved indirectly, e.g. through a funded transformation strategy (Module 5) or the use of energy management software (Module 3). The reporting of conceptual savings can be a solution here.

Issue #5: Changes in maximum permitted funding and funding rates

Even if this tends to be a minor problem, changes in funding rates may imply a lack of comparability between the results of the different evaluation years (keyword: transparency in reporting). As with the other issues, the effort involved in implementing new eligibility criteria within the evaluation scripts should also not be underestimated.

Conclusions

The aim of this paper was, on the one hand, to present the overall impact of the Federal Funding Scheme for Energy and Resource Efficiency in the Economy from the four evaluation rounds since 2019. On the other hand, the aim was to illustrate the EEE's evolution over the last five years to derive exemplary implications for the evaluation of dynamic funding schemes.

In terms of quantitative results, key performance indicators were first defined in order to review target achievement, effectiveness and economic efficiency of the EEE's measures, and then the aggregated evaluation results of these were presented. In total, the programme as a whole has achieved gross savings in GHG emissions of a good 4.8 million tonnes of CO₂ since its introduction until the end of 2022. The new savings from resource efficiency projects added in 2022 have had a significant positive effect here. Within the first four evaluation rounds, the funding volume reached almost 1.7 billion euros, resulting in triggered investments totalling 6.0 billion euros.

This makes the EEE a substantial public funding programme for energy efficiency in German industry.

Several issues and subsequent implications were identified with regard to the evaluation of dynamic multi-measure schemes. While there are always ongoing adjustments, it is important to distinguish major structural breaks to prepare for them in an ongoing evaluation. These can be changes to the directives during the year, newly added funding objects, adjustment of the scheme's targets, etc. For the evaluation, this means that it is important to be transparent about what is included in the respective indicators, to have differentiated reporting and to plan for potential delays in the implementation of the databases by the implementing agencies. Thus, it is advisable that policy-makers are aware that a redesign of a funding programme may also have substantial repercussions on its evaluation.

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