RESEARCH

Practices to collect and assess data on energy audits and energy management systems to inform the implementation of the European Energy Efficiency Directive

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Abstract The European Union's revised Energy Efficiency Directive (EED) obliges certain enterprises to conduct an energy audit or introduce an energy management system. This political instrument is expected to contribute to achieving the energy saving targets set by the European Union. However, the lack of comparable data in EU Member States complicates evaluations of its impact. A comparative analysis based on a collaboration between energy agencies from ten Member States shows different collection practices and varying availability of data on enterprises reporting an energy audit or energy management system. This indicates the need for harmonisation and standardisation of reporting processes and data collection to inform policy making. Furthermore, the analysis shows varying interpretations across Member States regarding the indicators on energy audits to be reported in their National Energy and Climate Progress Reports (NECPRs). To ensure good data quality in the NECPR database, the European Environment Agency should adopt guidelines and clear definitions for these indicators. The NECPR indicators proposed in this paper can serve as a basis for the European Commission to update reporting indicators under the revised EED. Moreover, Member States could agree to further harmonise their monitoring practices, including collecting and sharing data supplementary to the indicators reported via the NECPR. This paper suggests that they agree on a basic data set collected through their national procedures to monitor the energy audit and energy management system obligation under the EED. This paper proposes indicators for a basic data set to enable valuable impact analyses of this obligation.

Keywords Energy audit · Energy Efficiency Directive · NECPR · Data collection · Data assessment · Data standardisation

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Introduction

The contribution of energy audits (EA) and energy management systems (EnMS) to achieving energy savings has been subject of various studies carried out at national level (Plötz, 2017; BfEE, 2022; Gruber, Schlomann, and Friedewald, 2011; adelphi and IREES 2017; Herce et al., 2021; Marimon & Casadesús, 2017; Backlund & Thollander, 2015). The Member States of the European Union (MS) make use of their effects by including obligations for certain enterprises to carry out an EA or introduce an

EnMS in the European Energy Efficiency Directive (EED). The implementation of these obligations is intended to contribute to the EED objective of reducing the energy consumption within the European Union (EU). Prior to the last amendment of the EED in 2023, obligations related to EA and EnMS were specified in Article 8 (Directive 2012/27/EU). They are now set out in Article 11 of the EED, which also introduces new requirements. Under Article 11 of the revised EED, all enterprises recording an average annual energy consumption above 10 TJ per year in the previous three years must carry out an EA at least every four years. All enterprises with an average annual energy consumption of more than 85 TJ in the previous three years must implement an EnMS (Directive 2023/1791/EU). The MS are currently working on the transposition of these requirements into national law.

The results of this paper are derived from a comparative analysis carried out in 2024 within the project Leapto11.[1] The project is a collaboration between energy agencies from ten MS, namely Croatia, Germany, Greece, Ireland, Italy, Lithuania, Malta, the Netherlands, Portugal and Slovakia. It is co-funded by the EU.[2] For the procedure of monitoring the implementation of Article 11, all MS generate and process data. However, the analysis shows varying practices to collect, store and assess data related to EA and EnMS in the ten MS. This leads to varying availability and comparability of data, which complicates EU-wide analyses intended to inform policy making. Furthermore, there are varying interpretations across the MS of the indicators on EA to be reported in their National Energy and Climate Progress Reports (NECPRs). This leads to unreliable data quality in the database curated by the European

Environment Agency (EEA). The analysis shows a strong need for harmonisation and standardisation of reporting processes and data collection to enable an EU-wide analysis (Claus et al., 2024). Improved reporting can strengthen evaluations of the contribution of Article 11 to reaching the EED energy savings targets. Moreover, it can help to develop new and update existing policies. The work for this paper is thus guided by the following research questions: How could the reporting in NECPRs be improved and updated to better support evaluation of the EED? How could the reporting procedures within the MS to monitor the implementation of Article 11 be further harmonised to better support evaluation of the EED?

The paper contains recommendations for the European Commission (EC) and the MS to create a more harmonised data basis to enable better evaluations of the EED and its targets. It is structured as follows: After an overview of relevant works and an introduction to the methodology, it presents the results of the study. The paper then discusses the results and their limitations before deriving conclusions.

Background to this paper

Following adoption of the EED in 2012, several studies and reports examined the status of collection and utilisation of information stemming from Article 8 in the MS (Barkhausen, Hirzel and Durand, 2020; Eichhammer & Rohde, 2016; Hirzel et al., 2016; Nabitz & Hirzel, 2019, Serrenho, 2019; adelphi, 2023; DG Energy et al., 2022; Claus et al., 2024; Johnsson et al., 2025). It was pointed out that data on the implementation of the EA obligation by the MS is desirable since it provides valuable insights for future policy making and improved impact assessment. Furthermore, inconsistencies in reporting and monitoring procedures were repeatedly highlighted (Eichhammer & Rohde, 2016; Hirzel et al., 2016; Nabitz & Hirzel, 2019; Serrenho, 2019; DG Energy et al., 2022; Claus et al., 2024; Johnsson et al., 2025).

Given that data collection practices in the MS were scrutinised at different points in time, it is worth noting that the MS have strengthened their data collection procedures over time. In 2016, the MS collected too little data to adequately monitor the implementation of the EA obligation (Eichhammer & Rohde, 2016; Hirzel et al., 2016). By 2019, most MS had at

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[1] Further information can be found on the project website at www.leapto11.eu. The data used for this paper can be shared in an aggregated format upon request.

[2] The analysis is based on a cooperation between the Energy Institute Hrvoje Poža of Croatia (EIHP), the German Energy Agency (dena), the Center For Renewable Energy Sources of Greece (CRES), the Sustainable Energy Authority of Ireland (SEAI), the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), the Lithuanian Energy Agency (LEA), the Energy and Water Agency of Malta (EWA), the Netherlands Enterprise Agency (RVO), the Portuguese Energy Agency (ADENE) and the Slovak Innovation and Energy Agency (SIEA).

least basic monitoring procedures in place (Serrenho, 2019, 30; Nabitz & Hirzel, 2019). Since then, several MS have further improved their procedures, for example by introducing data collection via a digital form in an online portal (Claus et al., 2024, 29). However, the monitoring procedures comprise varying methods to collect, store and verify data. Recent analyses therefore continue to stress the need for harmonisation and standardisation of reporting processes and data collection in order to facilitate better evaluations (adelphi, 2023; Claus et al., 2024; Johnsson et al., 2025; Nabitz & Hirzel, 2019; Serrenho, 2019). Johnsson et al. (2025) even suggest centralising reporting through introduction of a common taxonomy for energy end-users. They also present a reporting template with indicators for such reporting at the industry process level (Johnsson et al., 2025, 14). Although such reporting would enable advanced evaluations, the adoption of additional reporting indicators integrated in the EU taxonomy is currently unlikely. This is indicated by the fact that the EC submitted proposals in February 2025 to simplify and reduce the information that enterprises must report under EU taxonomy (European Commission 2025a; 2025b).

Method of the analysis

The results of this paper are derived from a qualitative and quantitative comparative analysis carried out in the Leapto11 project. It is based on a questionnaire with 52 questions. The questionnaire was completed by experts of ten national energy agencies and supplemented by bilateral exchanges with them. Each question was connected to a table for the respondents to complete. The table consisted of either open fields to provide an answer or predetermined answers to be answered with "yes" or "no" or marked with a cross. Each table was supplemented by an open field to insert additional information and sources. Some tables included open fields to gather information on MS-specific barriers to data collection, monitoring or verification (Claus et al., 2024, 96–124). All experts completed the questionnaires from a country-specific perspective based on knowledge within their agency, desk research and with the assistance of other national institutions such as ministries, other national or regional agencies and research centres (Claus et al., 2024, 11). The questionnaire collected information on

the number of EA carried out in each MS in a similar format to information on the reporting on EA under the NECPRs. The numbers on EA in the questionnaires and the numbers extracted from the NECPR database showed discrepancies. A comparison of the data revealed that there are different interpretations in the MS regarding the data that should be reported in the NECPRs. For some of the indicators of such a basic data set, experts from the same ten national energy agencies completed an additional survey comprising seven questions. The answers in the questionnaires indicated which data is available in the ten MS. The insights were used to examine the indicators of the template by Johnsson et al. (2025) and to derive the basic data set proposed in this paper.

Results

This section presents the results of the analysis within the Leapto11 project (Claus et al., 2024) and relates them to recent work by Johnsson et al. (2025) and to data reported in the NECPR database.

Varying data collection, storage and verification practices in the MS

The analysis within the Leapto11 project shows that national institutions in all analysed MS systematically collect data on enterprises reporting an EA. However, only six out of ten MS systematically collect data on enterprises reporting an EnMS. In all ten MS, national institutions only collect such data through the procedures to monitor the EA obligation under the EED. Separate processes for data collection on EnMS are not in place, since an EnMS obligation was introduced only recently by the revised EED. Enterprises can fulfil the EA obligation under the EED by providing proof of an EnMS. They submit the data either when reporting on the EA they conducted or when reporting on their EnMS. Data collection, storage and verification procedures vary significantly in the ten MS. Information is collected either through a digital form in an online portal or via email. The storage solutions range from internal and externally hosted databases to Excel spreadsheets or, in some cases, no database at all. The analysed MS apply different methods to verify data collected through their procedures to monitor fulfilment of the EA obligation under the EED. Some national institutions verify all audit reports and even conduct on-site
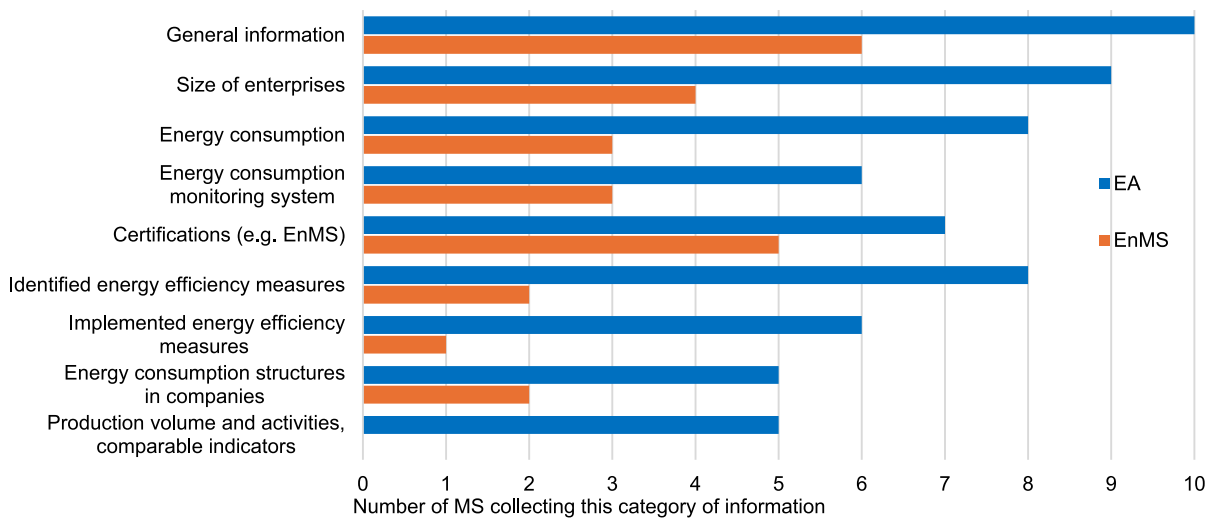
Fig. 1 Member states collecting different categories of information on enterprises reporting an EA or EnMS

spot checks to confirm implemented energy efficiency measures where such implementation is mandatory under national law.[3] In some MS, a statistically relevant number of EA reports are validated by random checks. Other MS only use online forms with basic pre-programmed plausibility checks when data is entered in the online portal. In these cases, no in-depth verification of audit reports takes place (Claus et al., 2024, 26–27, 35–36).[4]

Varying data indicators in the MS

The range of information collected on enterprises reporting an EA or EnMS also varies. Figure 1 shows different categories of information collected by procedures to monitor the EA obligation and how many of the analysed MS collect data in each category (Claus et al., 2024, 28–30). The fact that different MS collect data on different indicators complicates EU-wide analyses intended to inform policy making.

Varying utilisation of data for evaluations in the MS

At present, only a few MS are exploiting the potential of EA and EnMS reporting data to evaluate and tailor existing policies and develop new policies at the national level. Figure 2 shows the different purposes data reported on EA and EnMS is used and indicates how many MS use this data for each purpose.

Data reported on EnMS is used only in three of ten MS for purposes other than monitoring the EA obligation of companies that prove an EnMS as a substitute for a mandatory EA. In seven of the ten MS, the data reported on EA is used for systematic evaluation while in three it is used only in case of specific requests (Claus et al., 2024, 30, 35–36).[5] This shows room for improvement not only in the data basis but also in relation to systematic evaluation practices at national level.

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[3] The EED does not mandate the implementation of EEM after their identification through an EA. This means that an enterprise could carry out an EA every four years without taking any steps towards reducing its energy consumption. Some MS have therefore enacted national laws obliging companies to implement EEM identified in an EA.

[4] The source is supplemented by additional analyses based on answers in the questionnaires described in the methodology.

[5] Most institutions working with the data would like to broaden the range of information collected. The survey among experts in these institutions shows that they consider the collection of almost all types of data that have not yet been collected by them to be beneficial. Some parameters, such as the energy consumption structure or the production volume is not deemed necessary by all experts. The reason for that is most likely that the collection of this data can be resource-intensive for the enterprises concerned (Claus et al., 2024, 29).
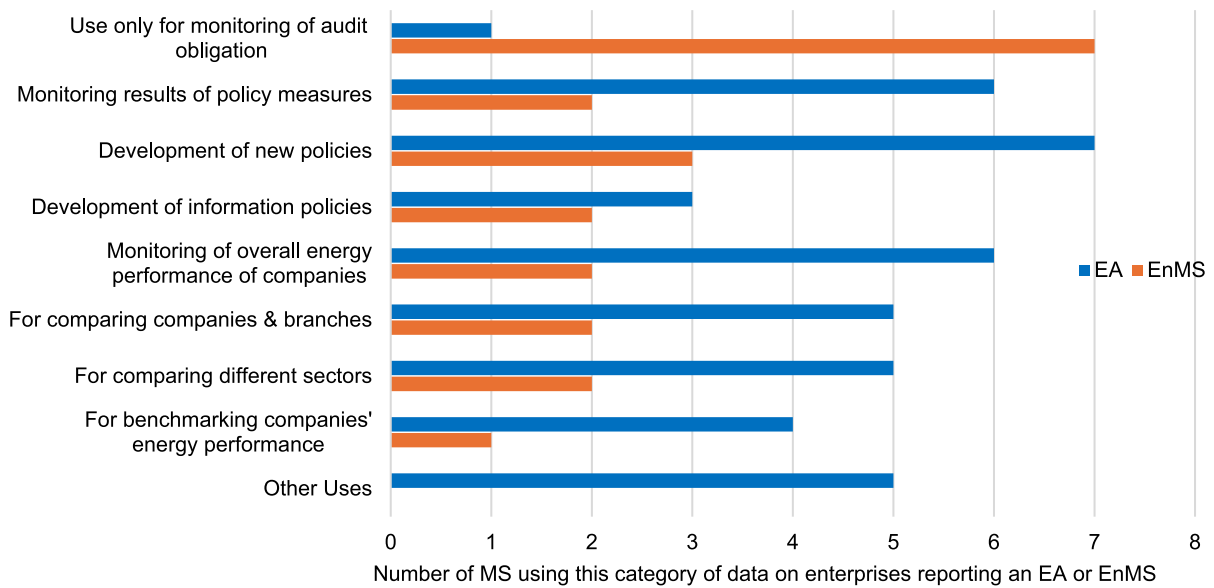
Fig. 2 Use of information on enterprises reporting an EA or EnMS in ten member states

Varying interpretations of NECPR indicators on EA across MS

In their NECPRs, MS must report data related to the impact of the EED (Regulation 2018/1999/EU, Annex IX, Part 2). The EC is mandated to adopt implementing acts "to set out the structure, format, technical details and process for the information" to be included in NECPRs (Regulation 2018/1999/EU, Art. 17(4)). According to Annex XVII of the Commission Implementing Regulation 2022/2299 of 2022, MS must report the following indicators on EA in their NECPRs (European Commission 2022):

- Total estimated number of large companies in their territory to which Article 8(4) of Directive 2012/27/EU is applicable
- Number of energy audits carried out in year three and year two before the report is due
- Number of energy audits carried out in large companies to which Article 8(4) of Directive 2012/27/EU applies in year three and year two before the report is due

The data on EA is collected in a database and published by the EEA (EEA, 2023). All ten analysed MS collect this data via a national framework mandating that enterprises report performance of an EA to the responsible institution. The answers collected via the questionnaire in the Leapto11 project and the NECPR data of the reporting year 2023 (EEA, 2023) reveal that the MS do not share the same understanding of the indicators to be reported. The analysis shows different interpretations of the reporting timespan, the target group and the question of whether voluntary energy audits should be reported. This is most likely due to variations in national implementation of the EED as well as varying data collection practices in the MS.

Varying interpretations of the reporting timespan

The analysis shows that the ten MS have differing understandings of the data to be reported to the EEA regarding the "total estimated number of large companies in their territory to which Article 8(4) of Directive 2012/27/EU is applicable". While two MS reported the number of enterprises which had to carry out an EA in 2021, eight reported the total number of enterprises subject to the EA obligation, including those for which an EA was not due in the reporting year. This indicates the need to more precisely define the reporting period for this category of data. If the data should refer to the second interpretation, clarification could be achieved by supplementing the indicator with a reference to the start date of the EA obligation in December 2015.

Varying interpretations of the target group of enterprises

Furthermore, the understanding of the target group of enterprises performing EA under the EED to be included in the reporting varies across the ten MS. The "total estimated number of large companies in their territory to which Article 8(4) of Directive 2012/27/EU is applicable" depends on the number of large enterprises covered by the EED, including any alteration of the target group under national provisions within the discretion of the EED. The same is true for the "number of energy audits carried out in large companies to which Article 8 (4) of Directive 2012/27/EU applies in year three and year two before the report is due".

Six of the ten analysed MS have altered the target group of "large companies" by including or excluding additional types of enterprises from the mandatory EA obligation under the EED (Claus et al., 2024, 16). This means that the numbers of large companies reported to the EEA database correspond to the total number of large companies only in four out of ten MS. They deviate to varying degrees in the remaining six MS. The impact of the EED is tied to the level of discretion exercised by the MS. Any analysis of the impact achieved by the EA obligation arising from the EED must take account of national alterations to target groups. When it comes to data collection for such assessments, it is crucial to ensure delineation between:

- a target group without any alteration,
- an expanded target group, and
- a reduced target group.

In some MS, such as Portugal or the Netherlands, national laws supplement the EED in a way that expands the target group of the EA obligation. However, the source of such expanded obligations is not necessarily the EED. For example, the Portuguese Management System of Intensive Energy Consumption (SGCIE), which mandates EA for energy-intensive enterprises, predates the EED (Decree-Law 71/2008). An impact analysis of the EED as a policy instrument must thus consider that the effect of expanded target groups cannot necessarily be attributed exclusively to the EED.

For the analysis in the Leapto11 project, the institutions in the ten MS were asked to indicate the number of obligated enterprises and the number of conducted EA required under to the EED audit obligation. The questionnaire did not explicitly ask to include large enterprises only. Therefore, the MS with an expanded target group interpreted this request in two different ways. One reporting method included all enterprises that were part of the expanded target group. The underlying interpretation here is that the impact of the expanded target group can be attributed to the EED. Another reporting method excluded any additional enterprises, so that the numbers were the same as if the target group would have not been expanded. The underlying interpretation here is that the impact of the expanded target group cannot be attributed to the EED.

The NECPR reporting indicators should therefore require the MS to extract the number of enterprises and EA that reflect the EED target group, without expanding the target group in any way. The Leapto11 project demonstrates that MS require a clear definition of the target group, since their interpretation of the indicator can differ. For example, the NECPR indicator asking for the "number of energy audits carried out in year three and year two before the report is due" lacks the requisite precision because the numbers reported indicate that the MS interpreted it in the two different ways described above. The indicators explicitly asking for numbers on "large enterprises" do not show such differing interpretations. Clarification could therefore be achieved by adding a reference to "large enterprises" to this indicator.

Varying reporting on EA carried out mandatorily or voluntarily

The obligations stemming from the EED are not the only motivation for enterprises to conduct EA or introduce EnMS, as they also provide a useful basis to take better decisions on investments in saving energy. Many MS offer programmes supporting enterprises in voluntarily conducting an EA or introducing an EnMS. Some national institutions collect data on EA carried out mandatorily and voluntarily in the same database. Others collect such information separately or do not collect any data on voluntary EA. These varying practices also lead to different interpretations across the ten MS regarding the data that should be

reported. The analysis shows that the NECPR indicator "number of energy audits carried out in year three and year two before the report is due" has been understood as referring to:

- the number of EA carried out mandatorily and
- the number of EA carried out mandatorily and voluntarily

The NECPR indicator should therefore be altered to clarify whether or not voluntary EA and EnMS should be reported.

Discussion

The following discussion includes proposals for adjusting two procedures for data collection on EnMS and EA within the EU.

Proposal for NECPR reporting indicators and guidelines under the revised EED

The varying interpretations regarding the NECPR indicators show that the EEA should adopt clear guidelines on data collection and reporting. These guidelines should set out definitions of the indicators to ensure high data quality. They should emphasise, for example, that it is possible that diverging target groups for the EA and EnMS obligations have been adopted in the MS and that reporting should not include expanded target groups. The MS should be made aware that their systems for collecting and storing the data can filter data to meet the specifications set out in the guidelines. Moreover, the indicators should be spelled out in full in the template used for data collection by the MS to avoid misunderstandings.

In Commission Recommendation (EU) 2024/2002 of 24 July 2024 on the interpretation of Article 11 of the revised EED, the EC reiterated in Number 11.1 and 11.2 that the MS must report indicators that were set in 2022 when updating their NECPR. However, the revised EED of 2023 introduces obligations to conduct an EA or introduce an EnMS based on the enterprises' energy consumption and no longer its size. The EC should adjust the reportable NECPR indicators to reflect these changes. It lies within its discretion to revise the 2022 Commission

Implementing Regulation 2022/2299, which indicates to the MS which information they shall include in their NECPR reporting. For future NECPR reporting, the following indicators on EA could be used:

- Total amount of **energy consumption** assessed by all **EA** carried out in enterprises that record an average annual energy consumption above 10 TJ per year in the previous three years (mandatory EA according to Art. 11 EED EU/2023/1791) **since the entry into force of such an obligation** (11 October 2026)
- Total amount of energy consumption assessed by all **EA** carried out in enterprises that record an average annual **energy consumption** above 10 TJ per year in the previous three years (mandatory EA according to Art. 11 EED EU/2023/1791) **in the reporting year**
- **Number of enterprises** recording an average annual energy consumption above 10 TJ per year in the previous three years (mandatory EA according to Art. 11 EED EU/2023/1791) **in the reporting year**

For future NECPR reporting, the following indicators on EnMS could be used:

- Total amount of energy consumption assessed by all **EnMS** in enterprises that record an average annual energy consumption above 85 TJ per year in the previous three years (mandatory EnMS according to Art. 11 EED EU/2023/1791) **since the entry into force of such an obligation** (11 October 2027)
- Total amount of energy consumption assessed by all **EnMS** in enterprises that record an average annual energy consumption above 85 TJ per year in the previous three years (mandatory EnMS according to Art. 11 EED EU/2023/1791) **in the reporting year**
- Number of enterprises recording an average annual energy consumption above 85 TJ per year in the previous three years (mandatory EnMS according to Art. 11 EED EU/2023/1791) **in the reporting year**

Separate reporting on the EA and EnMS obligations is desirable because it provides the basis to evaluate the impact of both instruments separately.

The number of mandatory EA or EnMS in the reporting year could be added as an additional indicator. Recording both the number of EA and EnMS and the energy consumption provides two ways of measuring the impact of these instruments. One way to measure the impact of the EED is to track the number of EA. The logic behind tracking the number of EA and EnMS is that the more enterprises implement EA or introduce EnMS, the higher the likelihood that a growing number of enterprises will recognise the potential of energy efficiency measures (EEM) and decide to implement them.[6] The logic behind tracking the energy consumption of enterprises conducting an EA or introducing an EnMS is that the more energy consumption is subject to an EA, the higher the potential for energy savings by EEM, and the higher the likelihood that EEM will be implemented. Likewise, the more energy consumption is subject to an EnMS and thus part of an iterative energy-saving process, the greater the potential for energy savings. Moreover, energy consumption data can be used to determine the share of total energy consumption in a MS subject to a regular process to identify potential savings.

New, clearly defined indicators should be used for reporting, since data collection on EA and EnMS obligations via the NECPR provides valuable insights into the impact of Article 11 of the EED.

Proposal for building a harmonised data basis to enable EU-wide policy evaluation

Different practices and varying availability of data on EA and EnMS in the ten MS complicate EU-wide analyses intended to inform policy making. If data collection was harmonised and standardised across the MS, it would facilitate EU-wide comparisons and evaluations to track the impact of existing policies

and support the development of new policies (Eichhammer & Rohde, 2016; Hirzel et al., 2016; Nabitz & Hirzel, 2019; Serrenho, 2019; DG Energy et al., 2022; Claus et al., 2024; Johnsson et al., 2025).

Johnsson et al., (2025, 14) provide a template for standardised data reporting through extension of the EU taxonomy. It serves the collection of "general plant information, production processes, support processes, key performance indicators, energy efficiency measures, and policy compliance indicators" and facilitate enhanced evaluations. A comparison of the indicators in the template with the categories of collected data in the ten MS shows the data already collected by the MS. An extension of the EU taxonomy is currently unlikely, and the indicators proposed in the template need data that is not yet widely available. However, the MS could take first steps toward creating a more harmonised data basis by agreeing to collect at least some indicators in a harmonised basic data set. Table 1 proposes indicators for such a basic data set. It is based on a comparison of the template by Johnsson et al. (2025) with the data already available in many of the ten MS analysed in the Leapto11 project. Since the MS already collect most of the indicators in their existing monitoring procedures, the basic data set would require less effort than the proposal put forward by Johnsson et al. (2025). It can be used to collect information within the national monitoring procedures of both the EA and EnMS obligations. The indicators proposed for the basic data set are not expected to affect the costs or acceptance of EA, since most of the required information is either easily available within the enterprise or part of an EA that meets the minimum quality criteria set out in Annex VI of the EED. Table 1 indicates how many of the ten MS already collect data for each indicator. An in-depth cost–benefit analysis lies beyond the scope of this paper. However, this proposal only includes indicators that contribute significantly to enabling analyses while posing minimal additional burden to enterprises.

All ten MS analysed in the Leapto11 project gather "general information" such as the address of the enterprise obliged to carry out an EA and the **date of reporting**. In order to facilitate EU-wide anonymised data processing and comparisons with control groups, national authorities should create an **anonymous enterprise identification number** for identification by national authorities only. Four of the ten MS

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[6] It must be noted that the obligation to carry out an EA is not, in and of itself, a guarantee that energy savings will be achieved. The question of whether to implement EEM identified in an EA lies ultimately with the decision-makers within an enterprise. Only a few MS have imposed obligations to implement EEM. By introducing the EnMS obligation and the obligation to publish "action plans" of enterprises in the revised EED, the MS are taking a step towards increasing the implementation rate of EEM. For a recent study on the question how the behaviour of decision-makers in enterprises impact EEM implementation, see Bensouda and Benali (2022).

Table 1 Indicators for a basic data set collected by all MS when monitoring the EA and EnMS obligations

Indicator suggested for a basic data set collected by the MS when monitoring the EA and EnMS obligations	Potential use of the indicator	Number of MS already using this indicator	Indicator is also part of the reporting template under an EU taxonomy suggested by Johnsson, Andrei and Johansson
General information			
Date of reporting	Enabling tracking over time	10/10	yes
Anonymous enterprise identification number for identification by national authorities only	Tracking compliance with obligation to implement EnMS or EA and basis for anonymised data evaluation	4/10	no
NACE code	Enabling sector-specific trends or comparisons	7/10	no
Final energy consumption over the previous three years (TJ/year)	Identifying obligated companies + indicator showing how much energy is assessed through an EA or an EnMS providing insight into the potential impact of the EA and EnMS obligation in reaching the energy saving goals of the EED	0/10 (8/10 collect data on the energy consumption)	no
Certifications, e.g. ISO 50001 or other, please specify	Tracking fulfilment of EA obligation through an EnMS + classification of the company in terms of its involvement with energy efficiency matters	7/10	yes
Report type (initial reporting or follow-up reporting)	Measuring impact of EA or EnMS (initial implementation or follow-up) over time by comparison with implemented energy efficiency measures in the respective reporting period	9/10	yes
Information on energy efficiency measures (to be completed for each measure)			
Name of measure (e.g., heat recovery, control technology optimisation)	Classification of measure	Identified: 8/10; implemented: 6/10	yes
Identified or implemented	Information on status of the measure	Identified: 8/10; implemented: 6/10	yes
Projected savings per identified measure (TJ/year)	Potential impact of the identified measure	8/10	yes
Projected savings per implemented measure (TJ/year)	Potential impact of the implemented measure	5/10	yes
Year of implementation of the measure	Information on the rate of action after an EA or introduction of an EnMS + rough indicator on the EEM uptake after carrying out an EA or introducing an EnMS + information on timespan between audit and EEM implementation	5/10	no

currently create such identifiers. Another indicator proposed for the basic data set is the enterprises' **NACE code** because this would make it possible to identify sector-specific trends and make comparisons. For example, data on the total energy consumption of audited enterprises in a given sector can then be set in relation to the energy consumption of the sector to indicate effects potentially yielded by EA or EnMS over time. Moreover, it allows typification and tracking of implementation rates of EEM in a sector. All this information can be used to tailor political instruments, such as funding. Currently, seven of ten MS store this information. The date of reporting, anonymous enterprise identification number and NACE code are indicators that can be created by public authorities and thus do not present an additional burden to enterprises.

Since the EA obligation under the prior EED was based on enterprise size, nine of ten MS currently collect this information. This indicator should be substituted by information on an enterprise's energy consumption because the EA and EnMS obligations under the revised EED now apply to energy-intensive enterprises irrespective of their size. Moreover, information on energy consumption indicates how much energy is assessed through an EA or an EnMS. It provides insights into the potential impact of the EA and EnMS obligation in achieving the energy savings goals of the EED. Eight of the ten MS already require enterprises to report information on their energy consumption. In most cases, however, only the total energy consumption is recorded and not the energy consumption of individual production processes or support processes (e.g. lightning, ventilation, etc.) as proposed in the template by Johnsson et al. (2025). The basic data set therefore deviates from the template. It proposes gathering the **final energy consumption over the previous three years** in line with the threshold relevant to obligations under Article 11 EED. As this information is an integral part of identifying the obligated enterprises, it must be recorded. Most enterprises have information on their energy consumption from energy bills, and the reporting burden is considered low.

The template and the basic data set both recommend collecting information on **certifications**, such as a certified EnMS within an enterprise. Seven of the ten MS gather this information. It can be used to track fulfilment of the EA obligation by proof of an EnMS

and makes it possible to classify an enterprise based on its ongoing engagement with energy efficiency matters. This information is typically available within enterprises, so the additional reporting burden is low.

Moreover, it should be recorded whether the enterprise is reporting on an EA or EnMS for the **first time or** is submitting a **follow-up report**. This indicator is also included as "report type" in the template by Johnsson et al. (2025). Tracking this can provide an assessment of the effectiveness of repeated EA or EnMS over the years by comparison to the implementation rate of EEM over time. Nine of ten MS already collect information on this indicator. Depending on the reporting templates, the indicator is either created by the authorities or submitted by the enterprise. Information on this indicator could be provided by the authorities based on the enterprise's date of reporting, address and NACE code, which would avoid placing an additional burden on enterprises.

For a better analysis of the impact of EA and EnMS as instruments that ultimately lead to energy savings, information on **identified EEM** and **implemented EEM** should be recorded. Information on EEM should include the **name of the measure**, its status as either **identified or implemented** and its **projected savings**. Information on EEM can be used, for example, to track the amount of potential energy savings, to track the type and number of EEM implemented following an EA or EnMS, to cluster economically viable measures by technologies or sectors or to tailor funding policies. The use of these indicators is suggested in the template and in the basic data set. Eight of the ten MS store information on EEM identified in an EA, while six store information on EEM implementation. Information on identified EEM is usually readily available within enterprises because it is included in an EA and forms part of the decision-making process to invest in EEM. Collecting information on this indicator is thus associated with little additional reporting burdens. Information on implemented EEM must be compiled by the enterprises and means additional work. However, the information can be used to fulfil the requirement under the revised EED, according to which enterprises must publish the implementation rate of measures within their so called "Action Plans".

The template and the basic data set suggest differentiating between planned and identified EEM to highlight the status of a given measure. However,

such differentiation does not make it possible to allocate an EEM to a specific EA or EnMS. The **year of implementation of a measure** should also be recorded to facilitate impact measurement over time. This indicator is not part of the template proposed by Johnsson et al. (2025) and is currently used by five of ten MS. Together with the indicator that tracks the date of reporting, the year of implementation serves as a rough indicator on the EEM uptake after carrying out an EA or introducing an EnMS and provides information on the rate of action as well as on the timespan between EA and EEM implementation.[7] Information regarding the year of implementation for an EEM is typically easily available within an enterprise and thus associated with little additional reporting burden.

The indicators in the template regarding production processes, support processes and key performance indicators are only partially collected at present. Only five of ten MS gather information on the energy consumption structure and on indicators useful for benchmarking, such as the production activity (Claus et al., 2024, 28–30, 35–36). The analysis shows that six of ten MS collect data on whether enterprises operate an energy consumption monitoring system. The template does not suggest collecting data on this indicator and, given the limited number of MS that currently collect such data, it is not included in the basic data set.

Only a few of the analysed MS collect any of the discussed categories of information on enterprises reporting an EnMS yet (Claus et al., 2024, 28–30, 35–36). The new EnMS obligation under the revised EED provides a chance to extend data collection on enterprises with an EnMS and thereby gain insights into the impact of the EnMS obligation.

With the transposition of the requirements of the revised EED, MS should consider agreeing a basic data set to be collected in their national procedures for monitoring implementation of EA and EnMS obligations under the EED. This data set should set common categories of information to be collected, such as those proposed in this paper. A decision by the MS to collect and share such information over a period of time would make it possible to conduct trend analyses indicating the impact of the EA and EnMS obligations. Collecting such data supports the policy evaluation and refinement, not only at EU level but also at national level. In order to ensure

comparable data quality, MS should agree on common minimum verification procedures for these data categories. In addition, MS should agree to ensure to make the data available in an extractable format, e.g. an Excel spreadsheet that is compatible and can be analysed with conventional software. In addition, it is crucial that MS agree on the exact timespan and the target group of enterprises for which data should be collected.

An agreement on a basic data set could take the form of guidelines supported by the EC and the MS. The EC recommends that the MS collect data on several indicators proposed in the basic data set, such as energy consumption and identified and implemented energy efficiency measures (European Commission, 2024, Number 4.4 and 5.1). This indicates that the EC might support such guidelines. A proposal for such an agreement could be prepared following an exchange between the EC and interested national institutions responsible for monitoring implementation of Article 11 EED. The proposal could then be discussed in the forum of the Concerted Action on the Energy Efficiency Directive (CA EED). The CA EED is financed under the European Union's Horizon 2020 research and innovation programme to support MS in the transposition and implementation of the EED. Interested MS could commit to the reporting guidelines and the group of MS could subsequently be expanded. The consolidation of information and EU-wide analyses could then be commissioned by the EC and results used for policy assessment of the EED.

It must be noted that the analysis in this paper is limited to 10 MS. Further research is needed to analyse data availability in the remaining MS. Once discussion on a possible agreement has progressed, further research will be needed to discuss the added

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7 In some MS, enterprises are not explicitly asked to submit information on the year of implementation of an EEM. Therefore, this data does not make it possible to "allocate" an EEM to a specific timeframe related to the EA. In this context, "allocation" refers primarily to temporal allocation and does not automatically indicate a causal relationship between the EA and the implemented EEM, given that other factors besides the EA can lead to the implementation of EEM. Nevertheless, asking specifically about the year of implementation is desirable because, otherwise, the exact same EEM could theoretically be reported again every four years despite being implemented several years ago.

value of these and other possible indicators for such a basic data set. Future research could examine which indicators are most valuable for evaluations compared to the costs to enterprises and national institutions in collecting them, and how national institutions should collect such data to ensure high data quality. The information gained by the basic data set can be used to track the progress of enterprises that report an EA or EnMS. However, in order to conduct comparisons with enterprises without an EA or EnMS, control variables are needed to exclude other causes for the analysed effect. The basic data set contains some indicators that can serve as control variables. These include information on whether the enterprise has an EA or EnMS, when the EEM were identified or implemented, whether it is an initial or follow-up reporting, which certifications the enterprise holds, and the sector to which it belongs. Further cost–benefit-analyses on specific research designs will be needed to decide whether other indicators such as enterprise size, turnover, energy consumption sources or use of subsidies should be included in the data set to serve as additional control variables. In addition, it should be investigated whether such data is not already requested under other reporting schemes and, if so, whether that data can be exchanged directly between authorities to avoid duplicating the burden on enterprises. Similarly, future research could investigate how the creation of new data interfaces to export data directly from EnMS for reporting purposes and the use of AI for data analysis could reduce costs.

Conclusions

The collection, storage and verification procedures for data on EA and EnMS in EU MS vary significantly. Moreover, there are differences in the categories of information collected. Many MS do not yet use data collected on EA or EnMS for systematic evaluations. The MS could make greater use of available data to evaluate and tailor national policies. Data currently available in the MS does not provide a sufficient basis for detailed evaluation of the contribution of the EA and EnMS obligations to the energy saving targets of the EED.

Moreover, there are varying interpretations across MS on the indicators concerning EA to be reported in their NECPRs. This indicates that the European Environment Agency should adopt clear guidelines on data collection and reporting including clear definitions of the NECPR indicators to ensure high data quality in its database. In addition, the European Commission should update the NECPR indicators to align them with the changes introduced by the revised EED. The NECPR indicators proposed in this paper can serve as a new basis for reporting under the revised EED. The indicators are based on the minimum thresholds of enterprises' energy consumption, which define the target group for EA and EnMS obligations under the revised EED. They are limited to data on mandatory EA and EnMS and indicate the timespan of reportable data. Gathering data on energy consumption instead of the number of EA and EnMS provides valuable insights into the impact of Article 11 of the EED because this data can be used to determine the share of total energy consumption in a MS subject to a regular process to identify potential savings.

In addition, MS could agree to further harmonise their current monitoring practices and collect and share data supplementary to the indicators reported via the NECPR. They could agree on a basic data set of information collected through their national procedures to monitor the EA and EnMS obligation under the EED. Such an agreement should set common categories of information to be collected along with minimum verification procedures for these categories. This paper proposes indicators for such a basic data set, which could easily be adopted because the MS already collect information on most of the indicators in existing monitoring procedures. The information collected by such a basic data set would enable valuable analysis regarding the impact of Article 11 of the EED. Such a data set could, for example, include the energy consumption and the EEMs identified and implemented by enterprises subject to EA and EnMS obligations. If the MS decide to collect and share information over a period of time, this will enable trend analyses to indicate the impact of EA and EnMS on energy savings.

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