Title
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Journal
Energy Policy, 216

ISSN
0301-4215

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Publication Date
2026-09-01

DOI
10.1016/j.enpol.2026.115198

Peer reviewed

Energy Policy 216 (2026) 115198

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/jepo

The global policy landscape of ISO 50001 energy management systems

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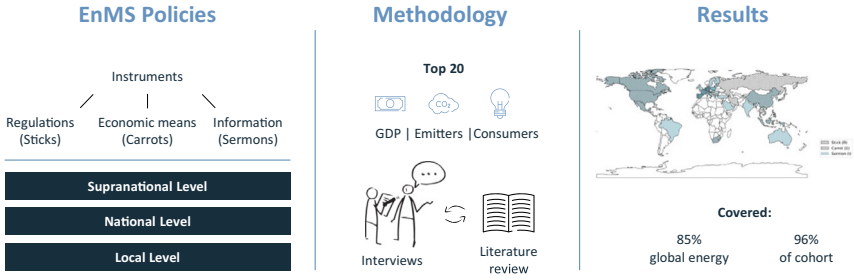
HIGHLIGHTS

- Deep industrial energy efficiency improvements are key to achieving national goals.
- ISO 50001-based energy management systems enable continuous energy improvement.
- We show that most significant energy consuming countries now have ISO 50001 policies.
- Major motivations for this are decarbonization, energy savings, and resilience.
- Policy mixes are more effective than standalone measures at fostering ISO 50001.

GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
Energy policy
Industrial decarbonization
Energy efficiency
Energy management systems
ISO 50001

ABSTRACT

While many options exist to improve industrial demand-side energy efficiency, energy management systems (EnMSs)—particularly those aligned with ISO 50001—are proven to drive continuous and meaningful energy performance improvements. Governments leverage these EnMSs in their policies to advance national objectives including enhancing industrial competitiveness and achieving environmental goals. Existing research has focused on the impact of EnMSs at the company level, while comprehensive work on EnMSs in a global policy context is lacking. We seek to close this gap by investigating the extent to which current national policies incorporate the utilization of EnMSs, particularly the ISO 50001 standard. Our paper employs a hybrid approach, combining a literature review and expert interviews across 28 governments representing > 86% of global primary energy consumption. We dissect policy mechanisms, governance levels, underlying motivations, and trends in present EnMS policies. We find that >96% of the investigated countries include EnMSs within their policy scope; 90% of policies including EnMSs utilize the ISO 50001 standard in some capacity. Primary policy motivations include decarbonization, energy savings for industrial competitiveness, and energy system resilience. We highlight that in the EnMS context, policy mixes—combining economic incentives, regulatory instruments, and information-based approaches—are more effective than standalone measures. Our work provides a novel global overview of governmental EnMS policies, moving beyond *whether* EnMS should be adopted to focus on *how* they can be implemented most effectively.

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https://doi.org/10.1016/j.enpol.2026.115198
Received 14 July 2025; Received in revised form 13 February 2026; Accepted 20 February 2026
Available online 23 May 2026

1. Introduction

For many energy users, actively managing energy with an energy management system can be an effective approach to increasing energy efficiency (Fitzgerald et al., 2023). Improving energy efficiency yields myriad benefits, including cost savings, improved industrial and commercial competitiveness, and furthering organizations' sustainability efforts. It also enhances energy security by reducing reliance on imports (Gökgöz and Güvercin, 2018), thereby increasing resilience (Aldieri et al., 2021) to geopolitical conflicts and supply disruptions like those witnessed in recent years (Ah-Voun et al., 2024). In addition, policy instruments like the European Union's Carbon Border Adjustment Mechanism (CBAM) and similar mechanisms under consideration in the U.S., Canada, U.K., Australia, and India will affect global trade. CBAM tariffs are scheduled to be assessed starting in 2026, penalizing goods with higher embedded carbon emissions and rewarding lower-emitting production. As a result, governments around the world are actively seeking mechanisms to promote energy efficiency as part of their strategies for competitiveness, resilience, and environmental objectives.

This paper investigates to what extent national policies around the world promote energy management systems (EnMSs) as a tool to meet their goals. We are especially interested in how these policies use the International Organization for Standardization (ISO) 50,001 energy management standard. Focusing on a cohort of 28 governments representing around 86% of global primary energy consumption (Ritchie et al., 2020), this paper dissects policy mechanisms, governance levels, underlying motivations, and trends in present EnMS policies around the world.

1.1. Background and literature review

Historically, energy efficiency has improved over time; however, the pace has been slower than needed to meet climate change goals. The IEA's most recent Energy Efficiency report as well as the United Nations Climate Change Conferences - Conference of the Parties (COP) 28 & 29 show that annual energy efficiency improvements should double from around 2% to at least 4% by 2030, to cut the energy demand by 10%, even as the global economy expands by almost 30% (International Energy Agency, 2023, 2024; COP28, n.d.; Owen-Burge, 2024). Efficiency measures provide some of the quickest and most cost-effective ways to reduce energy costs, cut carbon emissions, and yield other savings benefits, yet many barriers still impede (DeCanio, 1998) "achiev[ing] this rate of 4% consistently over a sustained period of time" (International Energy Agency, 2024).

Moreover, increasingly volatile energy markets and geopolitical uncertainties (Ah-Voun et al., 2024) as well as heightened competitiveness in global trade (Schmitz and Matthes, 2024) challenge nations to explore measures to support their local industry. As energy prices rise and put additional pressure on their respective industries (Schulze et al., 2016; Álvarez Ondina and Ibáñez de Aldecoa Fuster, 2022), governments are driven to support their industrial sector in improving energy performance (Thollander et al., 2013; Schulze et al., 2016).

EnMSs have been widely recognized as a tool that empowers relevant continuous energy performance improvements, reduces costs, and drives industrial decarbonization (Fitzgerald et al., 2023; McKane et al., 2017; António da Silva Gonçalves and Mil-Homens dos Santos, 2019). Published in 2011, the "ISO 50001 – Energy Management Systems" is the international standard that provides an international framework for the implementation of EnMSs. Governments seeking to strengthen their competitive position, reduce energy dependencies and/or meet their industrial decarbonization plans are increasingly leveraging EnMSs, and particularly the ISO 50001 standard.

Existing research on EnMS has primarily focused on the impact in industrial and commercial sectors. Studies have explored various aspects, including the effectiveness of EnMS and ISO 50001 implementation (Fitzgerald et al., 2023; Fuchs et al., 2023; António da Silva Gonçalves and Mil-Homens dos Santos, 2019; McKane, 2009; Fernando et al., 2018) the drivers behind their adoption (Fuchs et al., 2020), the implementation process itself (Fitzgerald et al., 2023; Therkelsen et al., 2018), and the characteristics of the ISO 50001 standard (McKane, 2009; António da Silva Gonçalves and Mil-Homens dos Santos, 2019; McKane et al., 2017). For instance, Fitzgerald *et al.* found that ISO 50001 delivers average annual year-over-year energy performance indicator (EPI) improvements between 4.1% in year one and 3.4% even 12 years post-implementation (Fitzgerald et al., 2023). Given the imperative for improved energy efficiency (International Energy Agency, 2023, 2024; COP28, n.d.; Owen-Burge, 2024), the demonstrated efficacy of EnMSs (Fitzgerald et al., 2023), and the recognition of EnMS policies as key implementation drivers (Fuchs et al., 2020), it can be inferred that the research on EnMS policies is highly relevant.

In summary, the impact of EnMSs at the company level, focusing on internal practices and performance is well studied and supports EnMSs as a significant tool for industrial decarbonization (Pushpo and Uddin, 2024; Fuchs et al., 2023, 2020). A second stream links EnMS to public policy, but typically in single jurisdictions or regions (Mai et al., 2017; Martini et al., 2025; Choi et al., 2018; Therkelsen et al., 2021; Bovkun et al., 2021) or treats EnMS primarily as instruments to support policy goals rather than as requirements embedded in policy (McKane et al., 2017; António da Silva Gonçalves and Mil-Homens dos Santos, 2019; McKane et al., 2017). McKane and colleagues suggested that the adoption and implementation of EnMSs, particularly the ISO 50001 standard, "will play a key role" (McKane et al., 2017) for governments seeking to reduce emissions and strengthen the competitive position of their industry. Their work included a compilation of existing national policies.

1.2. Research objectives

Prior work has not provided a comparative, global assessment of (i) which policy instruments explicitly reference or require EnMS, (ii) how deeply policies integrate ISO 50001 (e.g., compliance pathways, incentives), and (iii) the coverage across countries with a significant industrial base with high energy consumption and associated high greenhouse gas (GHG) emissions. In short, the literature to date lacks an evidence-based global map of EnMS-related policy design and uptake mechanisms. This blind spot limits our understanding of how governments currently leverage EnMS to deliver industrial energy efficiency and emissions reductions.

We seek to close this knowledge gap of EnMS policies and their mechanisms. Unlike previous research, which centered around the effectiveness of EnMS, our scope investigates how policies can increase the uptake of these proven standards and tools. At the core of this paper we seek to answer the research question:

To what extent do current national policies incorporate and promote the utilization of Energy Management Systems (EnMSs), particularly ISO 50,001 standards?

The answer to this question is especially relevant in light of the impact of policies like CBAM. Because ISO 50001-based EnMSs can be used to decrease the industrial climate impact and overcome related trade barriers, this paper is largely motivated by the need for deep industrial energy efficiency improvements. Thus, we chose a study cohort of relevant countries with the following criteria: having a significant industrial base, with high energy consumption and associated high greenhouse gas (GHG) emissions.

2. Methodology

To explore the policy landscape, we employed a hybrid approach, combining both primary qualitative research and document-based methods to gain a comprehensive understanding of a selected cohort. First, we identified a cohort of relevant governments based on specific criteria aligned with the research objectives. Next, the methodological

framework included two parallel components: (1) performing an extensive review of both existing legislation and related scientific literature, and (2) conducting interviews with experts and policymakers to capture insights into the legislative landscape to contextualize the findings. This combination of interviews and document review provided a solid foundation for examining the existing EnMS policy landscape across the selected cohort.

2.1. Research cohort

Before conducting literature review and interviews, we determined a cohort for which EnMS policies are most relevant. While EnMSs are useful to improve energy performance in any sector, the industrial energy improvements are the primarily targeted applications. With this lens, high EnMS implementation rates and thus EnMS policies are the most effective levers in countries with a) a large industrial sector that b) uses substantial amounts of energy, which c) emits high levels of CO_2.

We therefore set the following metrics to define the cohort:

(a) **High GDP** (World Development Indicators | DataBank, 2022)
(b) **Significant CO_2 emitters** (European Commission. Joint Research Centre., 2022)
(c) **Substantial energy consumption** (Energy Institute, 2023)

Our cohort consists of the top 20 countries for each of these respective rankings. Accounting for overlap, selection resulted in a list of 27 countries plus the European Union (EU27). Since the EU27 would rank third in emissions (European Commission. Joint Research Centre., 2022), energy consumption (Energy Institute, 2023), and GDP (World Development Indicators | DataBank, 2022) globally and has its own governmental body and legislation involving EnMSs, it appeared reasonable to assess the EU27 not just as a sum of its parts but as an entity by itself.

It should be noted that six entities within the cohort fall under current EU27 legislation, excluding the United Kingdom (UK), whose legislation has been heavily influenced by its past EU membership and transposition of European directives. The seven countries mentioned — France, Germany, Italy, Poland, Portugal and Spain — collectively represent roughly 6.5% of global primary energy consumption (Ritchie et al., 2020).

The 28 prioritized entities follow (listed alphabetically):

1. Australia
2. Brazil
3. Canada
4. China
5. EU27
6. France
7. Germany
8. India
9. Indonesia
10. Iran
11. Italy
12. Japan
13. Mexico
14. Philippines
15. Poland
16. Portugal
17. Russia
18. Saudi Arabia
19. South Africa
20. South Korea
21. Spain
22. Switzerland
23. Thailand
24. The Netherlands
25. Turkey
26. United Kingdom
27. USA
28. Vietnam

2.2. Policy literature review

As the initial part of the hybrid approach, we reviewed literature on the EnMS policies of all 28 entities named above. This primarily entailed the legislation on national and supranational governance levels surrounding energy management systems. We also took into account utility programs, industry association efforts, and municipal policies to accordingly represent regional governance levels. In addition to reviewing legislative texts, we reviewed IEA policy reports, policy databases, and scientific literature discussing specific EnMS policies.

2.3. Interviews

Secondly, to augment our literature review, we conducted expert and stakeholder interviews. The interplay of both information sources contextualized findings from the other. Most importantly, the interviews were helpful in interpreting legislation, as well as in identifying trends and supplementary resources.

The interviewees received a written questionnaire via email. When requested by the interviewee, we clarified upcoming questions in a conversation via 20–30 minute video calls. In the initial email we asked for an answer within two weeks, and followed up with two separate reminders if they had not responded by the initial deadline. In the interview process only the name, title, and country of each interviewee were recorded, with no other demographic information captured; nor did we ask any questions regarding their experience with energy management systems or any other related work experience. Our goal is to better understand the current landscape of EnMS policy and implementation, rather than to look into the human dimensions of this field.[1]

In the first iteration of interviews, we approached experts from the ISO technical committee (TC) with responsibility for energy management and energy savings, ISO/TC 301. Each member serves as an official representative for the respective country engaged in ISO 50001 standards development through the committee. The TC members could provide valuable perspectives on local requirements, measurability through reporting platforms, potential barriers, and projections. In a following iteration we contacted policymakers or government officials with a slightly changed questionnaire. From this peer group, we anticipated more information on the motivation, context, and future trajectory of the respective policy landscape. Interviews promised to reveal nuances that may not be captured in the literature alone. By combining the findings from the literature review with insights from expert and policymaker interviews, we gained a comprehensive understanding of the policy landscape surrounding EnMSs.

Over the course of the research period, we contacted 41 individuals, including 16 ISO TC 301 members and 25 government officials or agencies in 25 countries. As required by export control compliance at our home institution,[2] we refrained from contacting individuals in Iran and Russia. Fortunately, the literature review yielded sufficient insight for the EnMS policies of these countries. We are aware that a small and specialized interviewee group entails a certain response bias, with some of the interviewees acting in roles where they have an interest in steering the narrative or language around EnMS policies. Through our hybrid approach, we were able to address this bias by comparing the answers to legislation. In our analysis we additionally translated the semantic

[1] We consulted with our institution's Institutional Review Board (Lawrence Berkeley National Laboratory's Human and Animal Regulatory Committee Office) and received an official Not Human Subjects Research Determination.

[2] This research was funded by the U.S. Department of Energy and is subject to U.S. export control and sanction laws and regulations.

answers to numbers and binary statements to further minimize the effect of any potential language bias.

At the time of submission, we had received 12 answers, 29% of those invited. While we hoped for higher responsiveness, response rates for email surveys under 30% seem to be common (Sheehan, 2001). For example, Sheehan found a median response rate for email surveys of right under 37% and identified downward trend in her sample with her most recent samples averaging under 30% responsiveness (Sheehan, 2001).

2.4. Analysis

2.4.1. Quantitative analysis

To make the information we acquired through the literature review and interview process more accessible for further analysis and visualization, we translated semantic content into categorical and quantitative data. For each entity, we did this for the following items:

- EnMS covered by current policy (yes/no)
- Policy instruments
- Use of ISO 50001
- Policy level
- Measurability

2.4.2. Qualitative analysis

We also qualitatively addressed the underlying motivation of policy interventions and how these policies are projected to change in the coming years. This analysis of global trends and tendencies in EnMS policymaking paints a more detailed picture of how and why countries pursue or do not pursue energy performance improvements through EnMS. As part of Appendix B, we also include a brief qualitative policy summary for the respective countries.

3. Results

This section presents descriptive statistics and qualitative messages drawn from analyzing responses to interview questionnaires and the reviewed literature, representing energy performance interventions in 28 relevant countries or regions. Our study shows that the vast majority of countries identified as relevant already include EnMSs within their policy scope. Most of these interventions include or refer to ISO 50001 in their intervention. Our research showed that 86% of the policies are specifically related to decarbonization or environment Table 1. As we further investigated the many different policy instruments, two primary camps emerged: Bottom-Up and Top-Down approaches, consistent with the delineations provided by Ossenbrink as well as Rogge and Stadler (Ossenbrink et al., 2019; Rogge and Stadler, 2023). Top-Down policies mean policies with overarching strategic intent which are operationalized and transposed on lower levels, and Bottom-Up policies mean policies that enable and empower specific local domains to achieve their overall intent.

To classify and distinguish policy instruments and styles, we adopt Evert Vedung's nomenclature (Bemelmans-Videc et al., 1998). Vedung classifies the instruments into three categories: "Carrots", "Sticks", and "Sermons", which we will refer to as **Economic Incentives [E]**, **Regulatory Instruments [R]**, and **Information-based Instruments [I]**, respectively.

Economic Incentives [E] incentivize desired behavior through financial benefits such as grants, subsidies, tax credits, or market-based schemes. **Regulatory Instruments [R]** mandate certain behaviors and enforce compliance through penalties for non-compliance. **Information-based Instruments [I]** attempt to influence behavior through the transfer of knowledge, communication, and persuasion, rather than mandates or economic incentives. Note that the ISO 50001 EnMS standard by itself is an information-based instrument providing a "map" of actions to achieve improved energy performance (energy savings, elimination of energy waste, etc.).

3.1. Policy coverage

Our paper focuses on policies that explicitly include EnMSs. Policies only addressing energy management, energy audits, or incomplete implementation of EnMSs were excluded. Nevertheless, our research revealed that the vast majority of the cohort encompassed EnMSs in their efforts to improve energy performance.

Notably, over 96% of the respective countries' policies included EnMSs Fig. 1. In absolute terms – only one country, Switzerland, responded confirming no specific EnMS policy whatsoever. This can also be seen in Fig. 2, which shows that the cohort's energy performance policies almost unanimously cover EnMSs. Though few entities neglected the option of using energy management systems as a lever to improve their energy performance, we uncovered different levels of engagement between the policies.

Out of the investigated group, half of the entities chose to combine multiple instruments, applying a policy mix. Slightly fewer, around 46% chose to address EnMSs through one standalone instrument. We also found that countries employing policy mixes tended to place more importance and thus more effort into using EnMSs as a tool to improve energy performance. Literature shows that policy mixes "are needed to harness just transitions" (Kaljonen et al., 2024) as well as they are often more successful in solving the complex problems at hand while reducing tradeoffs (Howlett et al., 2022; Tchorzewska et al., 2025; Li et al., 2024; Jere et al., 2024).

3.2. Certification & ISO 50001

In our review, 90% (85% when taking into account Switzerland) of EnMS policies utilized ISO 50001 in some capacity. However, while many policymakers incorporated the standard into their frameworks, only some – mostly EU27 members – required formal ISO certification, which points to a bifurcated approach in the application of ISO 50001. Others built tools to facilitate energy management according to ISO 50001, provided information on the standard, or financially incentivized the certification.

By drawing upon ISO 50001, countries ensured a clear definition of EnMS under their respective jurisdiction. Adopting an ISO standard into legislation ensures consistency within the country and is more efficient than defining proprietary standards. Working within an internationally recognized framework also facilitates international cooperation and knowledge transfer. For countries that chose to sanction or reward enterprises in regard to their EnMS, ISO 50001 serves as a quality control tool that empowers them to leverage an existing certification process.

While a vast majority of countries incorporate the ISO 50001 standard into their EnMS policies, there are notable exceptions that often correlate with a less intensive approach to energy performance improvements. Specifically, Brazil, Iran, and Thailand do not include ISO 50001 in their policies. It's worth noting that Thailand's policy includes their own standard which is similar yet not equal to the ISO 50001 standard. All named countries employ standalone policies. It is significant, that all policies we considered to be comprehensive policy mixes included ISO 50001 to some regard (Figs. 3 and 4).

3.3. Instruments

Governments and other institutions with the authority and objective to influence group behavior or provide guidance have a multitude of tools at their disposal. While no intervention is exactly the same, policy instruments can be categorized along Vermont's dimensions introduced earlier (Bemelmans-Videc et al., 1998).

As mentioned in a previous section (see Section 3.1), the cohort divides into governments that rely on standalone measures and those that adopt policy mixes. Building on this, we also mentioned that policy mixes seemed to be the more comprehensive and nuanced approaches. Our impression for EnMS policies is congruent with what the general consensus that policy mixes are often more successful in solving the

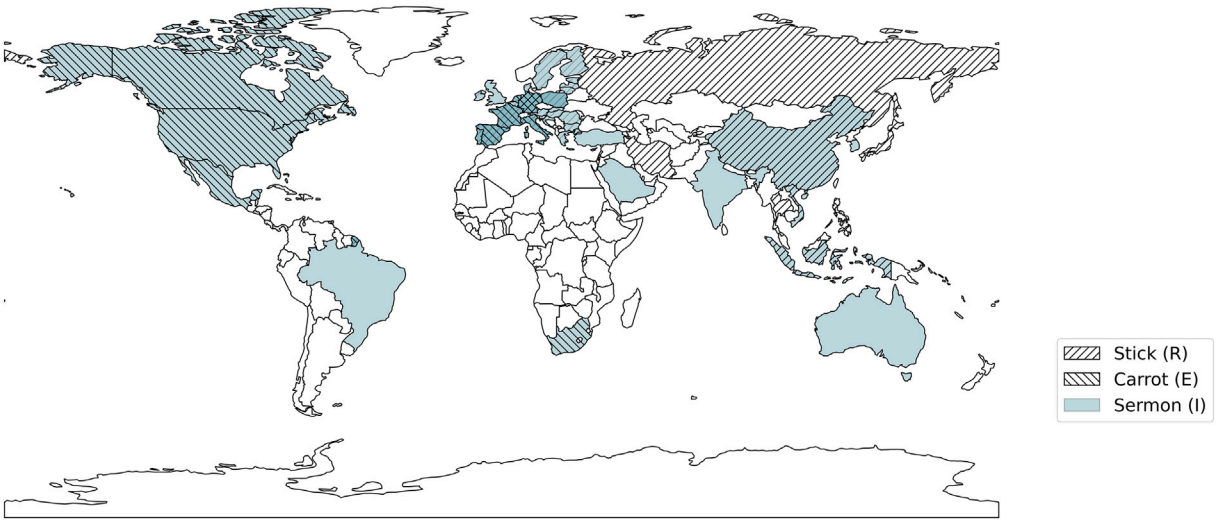

Fig. 1. Global EnMS policy coverage.

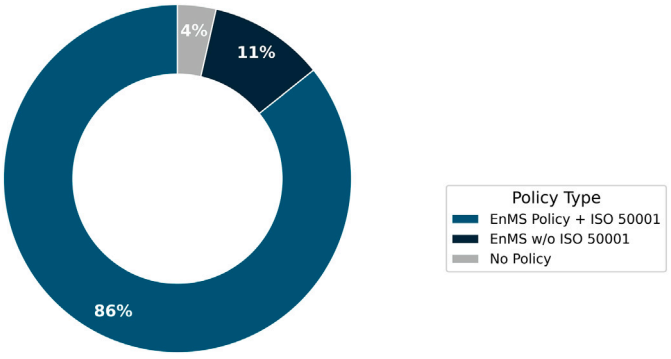

Fig. 2. ISO 50001 integration in policies.

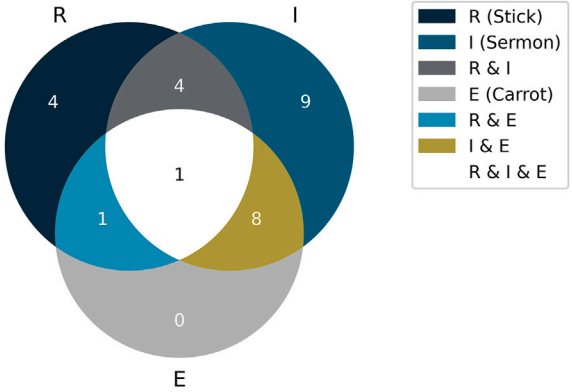

Fig. 3. Distribution of instruments in EnMS Policies.

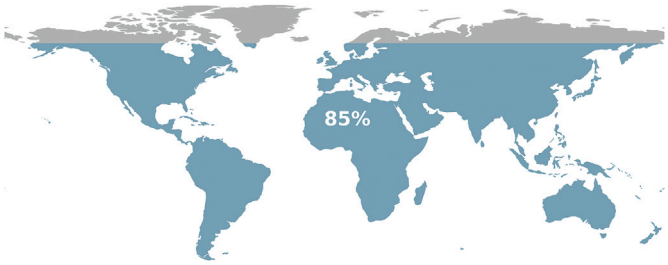

Fig. 4. Primary energy under EnMS intervention.

complex problems (Howlett et al., 2022; Tchorzewska et al., 2025; Li et al., 2024; Jere et al., 2024; Kaljonen et al., 2024).

3.3.1. Standalone

In the group of countries that employed standalone policies (Australia, Brazil, India, Iran, Japan, Poland, Portugal, Russia, Saudi Arabia, South Korea, Thailand, Turkey, United Kingdom), we saw that no country invested in economic incentives without supporting measures. Thus, we find there is a reluctance to make high financial investments in EnMS promotion without accompanying information. This underscores the importance of information-based measures as an enhancing tool within a policy mix. Information-based measures made up the bulk of standalone measures. Countries that employed standalone measures seemed to acknowledge EnMS as a tool, yet chose a low-effort approach to improving their energy performance.

Japan, Thailand, and Russia, chose a more restrictive path with 'Sticks' as their policy instruments. In particular, for Russia, the absence of persuasive methods appears to have had negative implications; while no interview was conducted with Russian experts, Bovkun et al. outline the issue in their paper (Bovkun et al., 2021). The paper describes how the Russian regulatory approach lacks a sufficiently motivating component and that enterprises seem to aim for conformance rather than actual performance improvements.

3.3.2. Policy mixes

Though many countries employed stand alone measures, we found that the bulk of the cohort employs more complex approaches using policy mixes (Canada, China, EU27, France, Germany, Indonesia, Italy, Mexico, Netherlands, Philippines, South Africa, Spain, United States, Vietnam). Among these combinations, policies integrating information-based components with either regulatory or economic interventions were the most frequently observed. Presently, the most common approaches revolve around the combination of economic incentives with information-based measures. With the transposition of the latest EU Energy Efficiency Directive (EED) iteration in the member states and

other future policy pushes, we will see a shift towards more regulatory approaches.[3]

Investing in informational campaigns, whether combined with regulatory or economic instruments, is the most common feature we observed across policy mixes. So called "sermons" are a popular approach to increase the acceptance and effectiveness of the policy. Bovkun and colleagues describe how the absence of a sufficiently motivating component [I] makes enterprises aim for conformance rather than actual performance improvements (Bovkun et al., 2021). In contrast, the only country employing all three instruments has been shown to be very successful. Germany, with only 1.3% of global industrial energy consumption (International Energy Agency, 2024, 2023), was able to achieve 20% of the global count of ISO 50001 certifications (ISO/CASCO - Committee on conformity assessment, 2022). The nation had incentivized large consumers to get ISO 50001 certified via tax subsidies; with the new EED, some of these subsidies have now become redundant with mandates that are part of the new European policy (EUR-Lex, n.d.). In the future, large consumers that fall under the mandate are not projected to receive redundant subsidies.

3.4. Governance level

Within the cohort we found a clear prominence of national-level interventions when it comes to EnMS policies. While policies at the national governance level appeared dominant, it is important to acknowledge that dispersed sub-national policies are often difficult to identify. Thus, the absence of unidentified policies could potentially skew our results. Among all entities, we could only identify four nations relying on more local interventions, three of which still had a national policy in place along with the local programs. Further, with the EU27's policy, there was only one supranational intervention within the scope of this study.

Our results suggest that countries employing EnMS policies in their national legislation cover at least 80% of the global emissions (European Commission. Joint Research Centre., 2023) and 85% of the global primary energy consumption (Ritchie et al., 2020). It was notable that three of the four countries that employed sub-national policies, namely Australia, Canada, and USA, all rely on voluntary implementation. Their policies all seem to be based on a bottom-up approach that empowers sites to employ EnMS via tailored local policies.

3.5. Measurability

Reliable data are essential for evaluating the effectiveness of EnMS policies, fostering accountability, and promoting continuous improvement. As part of the research, we inquired about the availability of public metrics related to EnMS policies. Implementing public data platforms would not only facilitate more robust policy evaluations and comparisons but also enable learning effects and best practice adoption across organizations and countries, rather than limiting the lessons about energy improvements within the borders of an enterprise.

Interviewees often pointed to general sustainability reports, typically separate from specific EnMS policies, as the primary source of information about EnMSs. Especially in EU27 member states, interviewees referred to the Corporate Sustainability Reporting Directive (CSRD). Rarely did we find policies that included or promoted data collection to further the measurability of the intervention.

With the new EU EED however, member states are obliged to provide data relating to their energy management to a central platform (EUR-Lex, n.d.). The recent criticism and subsequent postponement of the EU on its Corporate Sustainability Due Diligence Directive (CSDDD) underscore the challenges associated with implementing elaborate non-financial reporting mandates (Schickler, 2024). Balancing the need for comprehensive data collection with the burden on enterprises remains a key consideration for policymakers. Despite these challenges, the potential benefits of closing the data gap are substantial. The current EU27 legislation stipulates closing the data gap and the EED can be expected to be adopted by the member states in its current form.

3.6. Motivation

To understand what drives the integration of ISO 50001 EnMSs into policy, we examined the policies in our study cohort and the interviews we conducted for stated motivations. We found that most are related to advancing (industrial) decarbonization, with 86% of these policies specifically mentioning climate change and/or decarbonization as their underlying motivation.

Examine the underlying motivations for energy management policies, we find that decarbonization, right next to increasing energy savings and (energy) resiliency is the most important driver for creating such policies. This finding is consistent with the understanding that with almost three quarters of GHG emissions arising from energy use (Ritchie, 2020), the energy transition is the focal point of climate policy efforts. Although often primarily associated with renewable energy, energy efficiency plays a pivotal role in this transition. According to the Sustainable Development Scenario of the International Energy Agency (IEA), energy efficiency measures alone account for more than 40% of the emissions reductions needed by 2040 (International Energy Agency, 2021). Of the countries whose policies mentioned decarbonization and/or climate change as their primary motivation, 100% had signed the Paris Agreement. This alignment with global climate targets suggests a strong motivation to employ cost-effective methods for reducing industrial emissions, with EnMS being a key element. In addition, with the shifting landscape of global trade through mechanisms such as the EU's CBAM, we see that national climate policies will have more direct immediate effects across borders, encouraging cleaner industrial production more broadly. This suggests a strong motivation to employ cost-effective methods for reducing industrial emissions, with EnMS being a key element.

A secondary, but closely related, motivation is the pursuit of energy savings. This often aligns with the economic benefits for industries, and is advertised as such to win over big industrial stakeholders. However, the intention to save energy is not only driven by financial considerations, but also by sustainability (Commentaries, n.d.).

One notable exception to this framing, which relies on energy savings and decarbonization, is South Africa. Their primary motivation and root of the policy is energy savings for higher resilience (McKane et al., 2017). This divergence can be attributed to the country's significant challenges with load shedding, highlighting the critical need for a more reliable and resilient energy infrastructure (de Ruyter, 2023). Even though the idea of increased resilience was not seen elsewhere, it would still apply in other regions, especially as volatility in the grid increases globally. Given the often more precarious grid infrastructure and greater vulnerability to climate impacts in rapidly developing countries and the Global South, this approach could be especially relevant, with significant implications for equitable access to reliable energy. Gonçalves and dos Santos find that ISO 50001 positively contributes to sustainable development in the context of energy management (António da Silva Gonçalves and Mil-Homens dos Santos, 2019).

Overall, the motivations behind the adoption of EnMS and ISO 50001 policies underscore a global commitment to addressing climate change and enhancing energy efficiency, with economic and resilience considerations also playing important roles in shaping these policies Table 1. The suggested motivational drivers in EnMS policy making align with those industry lists as important motivations for EnMS implementation. As Fuchs and colleagues suggested in 2020, "Existing energy goals and values are the most common driver […] (72%)" and "Environmental sustainability […], and cost savings (48–54%)" come second in motivating industry to implement ISO 50001 energy management systems (Fuchs et al., 2020).

[3] The EED mandates that large consumers (average energy consumption over 3 years > 85 TJ) establish an EnMS (EUR-Lex, n.d.)

Table 1
Stated motivations in policy **x** (stated motivation) **dns** (did not specify) **N/A** (no relevant policy to examine).

Country/Entity	Environment, climate or decarbonization	Energy savings/ reduction of energy use	Resilience or grid stability	Source
Australia	x	x	x	Interview
Brazil	dns	dns	dns	Interview
Canada	x	x		Interview
China	x	x	x	(events, n.d.)
EU27	x	x	x	(energy-efficiency-directive, n.d.; EUR-Lex, n.d.)
France	x	x	x	(energy-efficiency-directive, n.d.; EUR-Lex, n.d.)
Germany	x	x		Interview
India	x	x	x	(programmesinternational-cooperationbilateral-programmes, n.d.)
Indonesia	x			(Republic of Indonesia, n.d.)
Iran	x			(H. of the Islamic Parliament, n.d.)
Italy	x	x	x	(energy-efficiency-directive, n.d.; EUR-Lex, n.d.)
Japan	x	x		Interview
Mexico	x	x	x	Interview; (Comisión Nacional para el Uso Eficiente de la Energía, 2019, n.d.)
Netherlands	x	x		(energy-efficiency-directive, n.d.; EUR-Lex, n.d.)
Philippines	x	x		(policies, n.d.)
Poland	x	x		Interview; (energy-efficiency-directive, n.d.; EUR-Lex, n.d.)
Portugal	x	x		(energy-efficiency-directive, n.d.; EUR-Lex, n.d.)
Russia	dns	dns	dns	(Bovkun et al., 2021)
Saudi Arabia	x	x		(regulations-laws, n.d.)
South Africa	x			(de Ruyter, 2023; Plessis du, 2015)
South Korea	x	x	x	(Shim, 2017)
Spain	x	x	x	Interview; (energy-efficiency-directive, n.d.; EUR-Lex, n.d.)
Switzerland	N/A	N/A	N/A	Interview
Thailand	dns	dns	dns	(Energy Conservation Promotion Act, 1992)
Turkey	x	x		(THE GRAND NATIONAL ASSEMBLY OF TURKEY, 2019)
United Kingdom	x	x	x	Interview
USA	x	x		Interview
Vietnam	x	x	x	(Department of Energy Efficiency and Sustainable Development, 2018)
Sum	**24**	**22**	**5**	
%	**85.7%**	**78.6%**	**17.9%**	

3.7. Outlook

After examining the policy landscape across the entire cohort, a trend toward incorporating EnMS within energy performance and decarbonization policies emerges. The research revealed that nearly every country in the cohort (96%) already includes EnMS in their current policies. The widespread adoption of EnMS policies suggests a growing consensus over time among governments, recognizing EnMS as a valuable tool for improving energy performance and achieving industrial decarbonization. Following the establishment of ISO 50001 in 2011, and the recognition and validation of EnMSs as a proven mechanisms for enhancing energy performance (McKane et al., 2017), a significant number of related policies have been implemented.

The consensus of policies using EnMS shifts the focus from *whether* to include EnMS to *how* to implement and optimize their use, as none of the stakeholders projected a backwards trend in the EnMS policy realm. Instead, we project future policies to become more rigorous and ambitious, reasons for this expectation are the statements throughout the interview process, the proven track record of the tool and last but not least the 27 member states transposing the EU's "North Star" policy.

Our interviewees reported that countries like Brazil, India, and Canada also seek to broaden their policies and Australia's Department of Climate Change, Energy, the Environment and Water (DCCEEW) reported they were seeking "ways the uptake of EnMS could be promoted [nationally]". Overall, the interviews yielded consistent feedback, with all participants either expressing satisfaction with the present integration of EnMS or outlining planned expansions of EnMS policies. Besides technical experts and policy stakeholders, industry stakeholders also seem to be mostly satisfied with higher adoption of EnMS in policy frameworks. In Germany for example, the country with the most extensive EnMS policy to date, those subject to the policy showed a positive level of satisfaction with the intervention (Mai et al., 2017).

In addition to the indicators mentioned, the number of mandates within our cohort will experience a stark increase due to the pending transposition of the EED in the EU27 member states. The EU27's policy is the most stringent and extensive intervention yet. However, the EU27 are not the only region trending towards more comprehensive EnMS interventions. Policymakers from all over the world mentioned they will "continue to implement" measures or already "suggested ways the uptake of EnMS could be promoted".

4. Conclusions and policy implications

Our paper provides a novel overview of how and why governments globally address EnMSs in their policies, narrowing the research gap pertaining to the EnMS policy landscape. It further analyzes the role of the ISO 50001 standard within these policies. Previous research has centered around how EnMSs and ISO 50001 support the pursuit of energy performance and emission targets. In contrast to previous work, we changed the perspective and investigated how governments aim to increase uptake and implementation of EnMSs and ISO 50001 to leverage their proven benefits.

4.1. Discussion

The results showed a near-universal utilization of EnMSs across relevant policies, mostly motivated by decarbonization (86%), energy saving (79%), and resiliency efforts (18%). Our paper, encompassing a cohort of 28 major economies responsible for over 87% of global CO_2 emissions from energy consumption, revealed that more than 96% of these countries have already integrated EnMSs into their policy frameworks. We found that the underlying motivations for governments were their decarbonization efforts, increasing energy savings for better industry competitiveness, and increasing the resiliency of their energy systems Table 1.

The questionnaire and literature review revealed that as of today ISO 50001 stands as a highly utilized tool in EnMS policies. Our research demonstrates that over 85% of the examined EnMS policies incorporate ISO 50001 in some capacity, highlighting its role as a framework for governmental interventions. By adopting the standard, policymakers gain a structured mechanism to delineate EnMSs within their respective jurisdictions via a consistent, standardized and auditable approach. Especially for mandates and economic incentives, it is helpful to use an established framework to describe the scope of an EnMS. An additional benefit mentioned by policymakers was that the ISO 50001 and associated standards continue to be updated to reflect best practices, diminishing the need for legislative revisions in countries making use of the standard. In essence, the widespread and prevailing use of ISO 50001 in global policies indicates that future policies will expand the use of the established standard.

4.2. Implications

While the widespread adoption of EnMS policies indicates a global consensus on the importance of EnMSs as a tool, we found significant variations in the approaches that governments take to include EnMSs and ISO 50001 in their policies. It must be mentioned that there is no "one-fits-all" approach to optimize EnMS uptake. The policies we reviewed represented the distinct cultural and systematic challenges unique to the respective regions.

We found that 51% of policy interventions employed policy mixes rather than relying on standalone measures. In line with the policy-mix findings introduced previously (Howlett et al., 2022; Tchorzewska et al., 2025; Li et al., 2024; Jere et al., 2024), these countries also demonstrated a higher commitment to energy performance improvements through EnMS implementation — particularly when supported by greater financial investment and an assumed willingness to expend political capital.

We find this to be particularly evident in the type of policies implemented. The vast majority of standalone measures observed were information-based policies; occasionally we also saw standalone mandates. These policies, while contributing to energy efficiency goals, require relatively low state investment and pose minimal political risk, making them easier to implement with little resistance. However, when it came to economic incentives, which often involve substantial financial allocations, not one government opted to introduce such measures in isolation. Instead, 100% of economic incentives were embedded within broader, more nuanced policy mixes that combined regulation, financial support, and information campaigns.

Economic incentives, due to their budgetary implications, might provoke political pushback. Similarly, policy mixes including stringent regulatory measures alongside financial mechanisms are more likely to polarize stakeholders and risk political capital. We suggest that financial investment and political risk are key determinants of policy ambition (OECD and United Nations Development Programme, 2025). Thus, the decision to implement policy mixes rather than standalone measures is not merely a matter of strategic effectiveness but also reflects a government's willingness to make significant financial and political commitments to drive energy performance improvements (Howlett et al., 2022; Kaljonen et al., 2024).

4.3. Limitations and future research

A significant impediment to the effective evaluation and comparative analysis of EnMS policies is the lack of readily available and reliable data. Additional reporting mandates are often frowned upon as they are perceived as additional barriers and cost drivers for the industry. Nonetheless, those implementing EnMSs will gather energy data as part of the process. While an additional reporting mandate might still be unpopular, the benefits of available data must not be underestimated. Reliable data would not only shed light on the impact of certain policies, but also create a better understanding of saving potentials across industries.

Limitations of our study stem from the aforementioned lack of data availability and only partial interview participation, narrowing the analysis primarily on policy design rather than quantified outcomes. Nonetheless, this does not undermine the study's main contribution: providing the first systematic and comparative mapping of EnMS policy frameworks across the world's major energy-consuming economies. Future research should build on this foundation through empirical evaluations of policy effectiveness, longitudinal analyses of implementation outcomes, and deeper investigation of behavioral and technological drivers of EnMS adoption. Future work could also elaborate on the effects of different policy approaches or explore how human factors and technological development play into EnMS implementation.

In the process of assessing global EnMS policies, it became evident that although policymakers' motivations are largely similar, their overall approaches vary significantly. Looking into the tools, levels, and motivations of policies there seem to be two underlying principles: Top-down and Bottom-up. Future research could ask questions such as "How do top-down and bottom-up EnMS policies differ in their mechanisms and effects?" or "What are the implications of voluntary versus regulatory approaches for EnMS?" Another intriguing angle on the differences in policy design is the comparative analysis of different policy approaches. Future work could compare and model the differences in uptake rate and implementation speed as well as energy under management and energy saved depending on the policy mechanism. The findings deduced from such analysis would help to make future policy making more efficient and effective.

Just as compelling as the policy dimension driving energy performance is the behavioral side of EnMSs and EnMS policies. Previous research has shown that making innovations more attractive to users improves their diffusion (Rogers, 1983). In a recent publication, Serra Coch suggested that this could also apply to EnMSs: making them more attractive to the consumer could positively affect adoption rates (Coch, 2023). How the type of intervention influences the motivation to improve energy performance or the effectiveness of the EnMS is a remaining area for further research, which might elucidate how policies can enhance intrinsic motivation, thereby making EnMSs even more effective.

Finally, regarding technology as a catalyst, recent developments might drive the diffusion of EnMSs without further political interventions. With technologies on the rise such as demand-side response (DSR), smart metering, smart production, and the Internet of Things (IoT), as well as sustainable reporting standards, energy data is likely to become an increasingly accessible and cost-effective asset. These innovations enable organizations to gain deeper insights and make the implementation of EnMS more intuitive. Not only would this lower the entry barriers for organizations, but it could also increase the learning effects and create new ways to find energy saving potentials through pattern recognition, learning networks, or large language models (LLMs). The intersection of these fields opens up more intriguing alleys for further research.

5. Conclusion

Overall, we found that EnMS policies emerged in two distinct camps: Bottom-Up or Top-Down interventions. We expect future policies to become more rigorous across both camps. Our expectation stems from interview insights, the proven effectiveness of EnMS, and the number of EU27 states adopting the EED as a "North Star" policy. The EED as the most stringent policy to date will consequently result in a growing gap between member states and the rest of the world. This divergence raises questions about the future of global EnMS policies and their effects. In sum, we see marked recognition of EnMSs as tools for better energy performance and lower GHG emissions. With countries responsible for at least 80% of global emissions and 85% of global primary energy consumption having some type of EnMS policy in place, governments worldwide have embraced EnMS as a cornerstone of their sustainability

strategies. Given that EnMS policies and programs are now widespread, research and practice should move beyond the question of *whether* EnMS should be adopted to focus on *how* they can be implemented and achieve their aims most effectively and expeditiously.

CRediT authorship contribution statement

Francisco Luis Moreno: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Heidi Fuchs:** Writing – review & editing, Supervision, Methodology, Conceptualization. **William Miller:** Writing – review & editing, Methodology. **Peter Therkelsen:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used GPT and NotebookLM in order to scan legislation and clarify wording. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

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Appendix A. Overview table

See Table A.2.

Table A.2
Global EnMS policies.

Entity	EnMS	Instruments	ISO 50001	Level	Sources
Australia	✓	I	✓	L	Interview
Brazil	✓	I	×	N	Interview; (McKane et al., 2017)
Canada	✓	E, I	✓	N, L	Interview; (McKane et al., 2017)
China	✓	R, I	✓	N	(Lu et al., 2014; Lewis, n.d.; wp-content, n.d.; digichina, n.d.; good-practice-database, n.d.; kms_object, n.d.; events, n.d.)
EU27	✓	R, I	✓	S	(EUR-Lex, n.d.; energy-efficiency-directive, n.d.)
France	✓	E, I	✓	N	(McKane et al., 2017; Moutet and Fouquet, 2018; pro-smen, n.d.; EUR-Lex, n.d.; energy-efficiency-directive, n.d.)
Germany	✓	R, E, I	✓	N	Interview; (McKane et al., 2017; EUR-Lex, n.d.; energy-efficiency-directive, n.d.)
India	✓	I	✓	N	(McKane et al., 2017; news, n.d.; programmesdemand-side-managementsmall-medium-enterprise, n.d.; programmesinternational-cooperationbilateral-programmes, n.d.)
Indonesia	✓	R, I	✓	N	(Compendium of Energy Efficiency Policies of APEC Economies, 2015; Republic of Indonesia, n.d.; policies, n.d.)
Iran	✓	R	×	N	(H. of the Islamic Parliament, n.d.)
Italy	✓	E, I	✓	N	(efficiency-trends-policies-profiles, n.d.; Government of Italy, 2020; EUR-Lex, n.d.; energy-efficiency-directive, n.d.)
Japan	✓	R	✓	N	Interview; (McKane et al., 2017; Ministry of Economy, Trade and Industry , METI)
Mexico	✓	E, I	✓	N	Interview; (McKane et al., 2017; Comisión Nacional para el Uso Eficiente de la Energía, 2019; cleanenergyministerial, n.d.; Comisión Nacional para el Uso Eficiente de la Energía, n.d.)
Philippines	✓	R, E	✓	N	(Senate of the Government of the Philippines, 2019; policies, n.d.)
Poland	✓	I	✓	N	Interview; (EUR-Lex, n.d.; energy-efficiency-directive, n.d.; IEA, 2022)
Portugal	✓	I	✓	N	(EUR-Lex, n.d.; energy-efficiency-directive, n.d.; Ministério do Ambiente, Ordenamento do Território e Energia, 2015)
Russia	✓	R	✓	N	(Bovkun et al., 2021)
Saudi Arabia	✓	I	✓	N	(regulations-laws, n.d.; Das, 2023)
South Africa	✓	E, I	✓	N	(McKane et al., 2017; de Ruyter, 2023; Plessis du, 2015)
South Korea	✓	I	✓	N	(McKane et al., 2017; policies, n.d.; Shim, 2017)
Spain	✓	E, I	✓	N	Interview; (EUR-Lex, n.d.; energy-efficiency-directive, n.d.)
Switzerland	×	none	×	none	Interview
Thailand	✓	R	×	N	(McKane et al., 2017; Wongsapai, 2016; Energy Conservation Promotion Act, 1992)
Netherlands	✓	E, I	✓	N,L	(EUR-Lex, n.d.; energy-efficiency-directive, n.d.; Legal-Content, 2023, 2012)
Turkey	✓	I	✓	N	(McKane et al., 2017; THE GRAND NATIONAL ASSEMBLY OF TURKEY, 2019)
United Kingdom	✓	I	✓	N	Interview; (McKane et al., 2017; Department for Energy Security and Net Zero, Environment Agency and Department for Business, Energy & Industrial Strategy, 2024)
USA	✓	E, I	✓	N,L	Interview; (McKane et al., 2017; Consortium for Energy Efficiency, 2024; U.S. Department of Energy, 2024; Sheaffer et al., 2016; Fuchs et al., 2020; Therkelsen et al., 2015, 2021)
Vietnam	✓	R, I	✓	N	(Department for Energy Security and Net Zero, Environment Agency and Department for Business, Energy & Industrial Strategy, n.d.; Department of Energy Efficiency and Sustainable Development, 2018)

Instruments: **R** (Stick - Regulatory Policy) **E** (Carrot - Economic Policy) **I** (Sermon- Information-based Policy)
Level: **S** (Supranational) **N** (National) **L** (Local)

Appendix B. Policy details

Australia

"The Commonwealth of Australia is considering the role of energy management systems in accelerating and unlocking the energy transition, to drive decarbonisation and to drive a least cost pathway to net zero" (Interviews). Yet, Australia has no national policy or metric on Energy Management Systems, but mentions ISO 50001 and EnMS on the governments internet presence (t. E. Department of Climate Change, Energy and Water, 2024). Even though there is no national policy, we could identify some local (state) policy efforts. We were specifically made aware of programs in New South Wales, such as the NSW Energy Management Services Program and the NSW Business Decarbonisation Initiative. After further review, we found that elementary parts of the information presented by the national government rely on local tools, whose development was backed by the Energy Efficiency Council (EEC). The EEC is currently researching "the potential to expand the use of EnMS in Australia." (Interviews)

As "the EEC noted the potential benefits of EnMS and suggested ways the uptake of EnMS could be promoted in Australia, drawing on the experience of other countries" (Interview), we are expecting the rollout of national policies in Australia in the future. 'They found that both voluntary programs and targeted incentives have worked in the US (…) Germany (…) and Spain (…)".

Brazil

Brazil currently has no programs or regulations specifically focused on Energy Management Systems (EnMS). Hence, there are no established metrics related to EnMS. However, national efforts targeting energy efficiency include the promotion of EnMS through information-based policies. Even after thorough investigation, we are not aware of any local policies supporting EnMS, nor were any mentioned to us.

Canada

Canada has a comprehensive policy mix for Energy Management Systems (EnMS). The policy mix is one of the more elaborate ones that we observed throughout my research. The policy framework includes both financial incentives and information-based initiatives. We identified both tools at the national level and local levels in provinces such as Ontario and Quebec. Notably, Canada employs tools within their 'sermon' policies, that were developed as part of the US DoE and Energy Star programs.

China

China's most elaborate EnMS policy is the Top-10,000 Enterprises Energy-Saving Program, initiated under the 12th Development Plan and continued through the 13th and 14th Development Plans. Launched in 2011, this program targets around 15,000 enterprises, accounting for two-thirds of China's total energy consumption. It mandates that enterprises establish EnMS in compliance with the national standard GB/T 23331, aligned with ISO 50001. Certification and oversight are managed by the Certification and Accreditation Administration (CNCA). Enterprises must set specific energy-saving targets, conduct regular energy audits, and submit detailed energy conservation plans. Provincial energy conservation authorities support local implementation and enhancement of EnMS, contributing significantly to China's national energy conservation goals outlined in its Five-Year Plans (Lu et al., 2014; Lewis, n.d.; wp-content, n.d.; digichina, n.d.; good-practice-database, n.d.; kms_object, n.d.; events, n.d.).

EU27

The European Union's EnMS policy mix is characterized by a top-down approach, with regulatory and information-based mechanisms formalized in the EED. The EED, initially adopted in 2012 and revised in 2018 and 2023, establishes a framework for EU member states to achieve energy efficiency targets. The latest iteration, EU/2023/1791, significantly expands the role of EnMS and ISO 50001. The revised EED mandates the implementation of ISO 50001-certified EnMSs for large enterprises with annual energy consumption exceeding 85 TJ. This mandate represents a significant shift from previous iterations, which allowed for alternative compliance pathways.

While previously, energy audits were only mandatory for large enterprises, they are now a requirement for SMEs with "significant energy-saving potential" (consuming over 10 TJ yearly). These SMEs are granted an exemption from energy audits if they implement an ISO50001-certified EnMS, a mechanism previously used for large enterprises.

The new EED requires both large enterprises and SMEs subject to its provisions to develop and implement action plans based on the recommendations arising from their audits or EnMS implementations. This emphasis on action plans underscores the EU's focus on translating energy management efforts into concrete energy savings. The EED also entails the establishment of energy data centers (EUR-Lex, n.d.; energy-efficiency-directive, n.d.).

France

France has implemented comprehensive policies for Energy Management Systems under the 2012 Energy Efficiency Directive through the DADDUE Law of 2013. This includes mandatory energy audits for large enterprises, with exemptions for those certified under ISO 50001. The law mandates that energy audits cover a significant portion of the company's energy consumption and must be conducted by qualified auditors. Penalties for non-compliance can reach up to 2% of the company's turnover. Furthermore, France has introduced the PRO-SMEn financial incentive program for 2023-2026, offering up to €40,000 to companies implementing ISO 50001-compliant EnMS. This program is supported by a fund of €11.2 million, contributed by five energy suppliers in exchange for energy savings certificates. (Moutet and Fouquet, 2018; pro-smen, n.d.) A new EED mandate for large consumers is expected to be transposed by the end of 2025 (EUR-Lex, n.d.).

Germany

Germany has formerly invested heavily in incentivizing EnMS. They exceeded the European legislation achieving the globally highest number of ISO 50001 certificates (ISO/CASCO - Committee on conformity assessment, 2022). It can be said that Germany has the most rigorous policy mix employing incentives and mandates to push widespread EnMS implementation. The early engagement in widespread EnMS policy interventions led to a handful of redundancies with the newest iteration of the EED. These redundancies are expected to be eliminated and incentives will likely be directed towards smaller size companies implementing EnMS.

India

There is very limited information available on India's EnMS policy activities. The Bureau of Energy Efficiency (BEE) participates in learning networks and the Energy Management Working Group. The Bureau seems to occasionally hold workshops and engage in international outreach programs. Additionally, the BEE has announced plans to introduce ISO 50001:2018 energy management standards in energy-intensive industries across all states, however we were not able to find such legislation anywhere. All available information suggests that India and the BEE support EnMS but currently maintain a minimal effort information-based policy approach (news, n.d.; programmesdemand-side-managementsmall-medium-enterprise, n.d.; programmesinternational-cooperationbilateral-programmes, n.d.).

Indonesia

Indonesia has implemented a mandatory Energy Management Program for large energy users consuming 6000 TOE or more. This program requires companies to establish an energy management system, appoint an energy manager, conduct regular energy audits, implement energy conservation programs, and report to the government.

Additionally, the government supports companies in adopting the ISO 50001:2011 Energy Management System Standard (policies, n.d.; Republic of Indonesia, n.d.; Compendium of Energy Efficiency Policies of APEC Economies, 2015).

Iran

Iran has a regulatory approach with a rather small target group: Law No. 1770 of 2011 on Energy Consumption Pattern Reform mandates the implementation of EnMS in public buildings. The law also requires the establishment of obligatory energy management units for sectors such as power, refinery, and petrochemical industries. Additionally, it mandates EnMS for energy consumers who use over five million cubic meters of gas annually or an equivalent amount of liquid fuel, as well as those with electrical power demands exceeding one megawatt (H. of the Islamic Parliament, n.d.).

Italy

Italy has transposed previous versions of the EED into its regulatory framework, with Legislative Decree No. 73/2020 incorporating the EU Directive 2018/2002 and the Energy Efficiency First Principle. Along those lines, it includes an energy audit mandate for large consumers and an exemption of this mandate for companies with ISO 50001 certification. The decree provides incentives for SMEs to implement ISO 50001 energy management systems and conduct energy audits every two years until 2030. Additionally, it initiated the new Conto Termico by June 2021 and extended both the National Energy Efficiency Fund and the Programme for the Energy Renovation of Central Public Administration Buildings (PREPAC) to 2030. Italy is also set to transpose the new EED, including the mandate for large consumers, by October 2025 (Government of Italy, 2020; efficiency-trends-policies-profiles, n.d.).

Japan

Japan has a unique approach to its Energy Management System policy. The country chose a regulatory approach with no financial penalty attached, however there is a unique wrinkle that incentivizes companies to comply with the mandate. Companies with a total energy consumption of 1500 kl of crude oil equivalent or 6730 MWh or more. Rather than financial penalties, non-conformance or underperformance will lead to public shaming by the government. Bad performance is defined as less than 1% improvements for more than one year. Non conformance equals not having an EnMS in place. (Interview); (McKane et al., 2017; Ministry of Economy, Trade and Industry , METI).

Mexico

In Mexico, EnMS are mandated for a small group of State Productive Companies in the energy sector (Petróleos Mexicanos, Federal Electricity Commission). Private industries are encouraged to voluntarily adopt EnMS under internationally recognized standards, with users of high energy consumption patterns targeted. EnMS are further promoted through the PRONASGEn program, which aims to overcome barriers to energy efficiency and support the formal adoption of EnMS. PRONASGEn operates through learning networks, involving consulting firms, educational institutions, and international collaboration to support EnMS implementation and develop national and international experts. The program has expanded its reach to other Latin American countries to facilitate EnMS adoption across different sectors (Interview).

Philippines

In 2018, the Philippines implemented Republic Act No. 11,285. The law mandates designated establishments to integrate an Energy Management System compliant with ISO 50001 Tier or similar standards. Designated establishments are those with an annual energy consumption of 500 MWh or more. Additionally, the Philippines promotes the adoption of EnMS to all other establishments to enhance energy efficiency and conservation efforts nationwide.

Poland

Poland's current policy regarding Energy Management Systems aligns with the old Energy Efficiency Directive, featuring an energy audit mandate for large consumers. However, companies with ISO 50001 certification are exempt from this mandate. Poland is set to revise its policy in accordance with the new EED, which includes a mandate for large consumers. (Interview) (EUR-Lex, n.d.; energy-efficiency-directive, n.d.; IEA, 2022).

Portugal

Portugal's current policy on EnMS is based on Decreto-Lei n.º 68-A/2015, which aligns with the 2012 Energy Efficiency Directive. The policy mandates energy audits for large consumers, with exemptions for companies holding ISO 50001 certification. Portugal is set to revise its policy to comply with the new EED, which will include additional mandates for large consumers. We are not aware of any other incentives or local policies (Ministério do Ambiente, Ordenamento do Território e Energia, 2015).

Russia

Russia has several regulatory policies on EnMS and ISO 50001. The policies require companies to obtain a conformity certificate by acquiring an ISO 50001 certification. Literature suggests that the policy has faced challenges such as a lack of genuine interest in actual energy management, financial constraints, low employee motivation, and insufficient practical experience. Many companies focus on formal compliance to pass audits rather than achieving real improvements in energy efficiency (Bovkun et al., 2021).

Saudi Arabia

Saudi Arabia promotes the use of the US Department of Energy's 50,001 Ready program for EnMS adoption. Additionally, obtaining an ISO 50001 certification in Saudi Arabia can lead to reduced insurance premiums, incentivizing organizations to implement EnMS.

South Africa

South Africa has implemented several programs and initiatives to promote Energy Management Systems and ISO 50001 certification. The Industrial Energy Efficiency (IEE) Project, established in 2010 with multiple international and national partners, aims to enhance energy efficiency in industries, train professionals, and support the implementation of ISO 50001 standards. The Energy Efficiency and Demand Side Management (EEDSM) Program, initiated by Eskom in 2002, complements ISO 50001 by promoting systematic energy management practices. Tax incentives introduced in 2013 encourage businesses to adopt energy efficiency projects and seek ISO 50001 certification. While there is no EnMS mandate, the Department of Energy mandates energy management plans for enterprises with annual energy consumption over 180 TJ, supporting these initiatives with financial incentives and resources. Proposed learning hubs aim to further facilitate ISO 50001 certification by raising awareness and providing support for the certification process (Plessis du, 2015; de Ruyter, 2023).

South Korea

South Korea's EnMS programs rely on Article 28–2. The article encourages energy users or suppliers to implement company-wide energy management systems for enhanced energy efficiency. The law mentions an incentive to implement ISO 50001, however after further review we found it consists of exemptions from mandatory energy audits, similar to the former Energy Efficiency Directive. South Korea also provides the ENPI tool which is similar to the US DoE's tool. The tool is part of their information-based approach to offering technical support for EnMS implementation (McKane et al., 2017; policies, n.d.; Shim, 2017).

Spain

Spain is set to revise its policy according to the new EED, which will include mandates for large consumers. The current policy, under Royal

Decree 56/2016, aligns with the old EED and mandates energy audits for large consumers, exempting companies with ISO 50001 certification. Additionally, the adoption of EnMS is a precondition for inclusion in some public tenders. A policy revision is forthcoming to align with the new EED requirements.

Switzerland

Switzerland has no specific policy for Energy Management Systems (EnMS). According to the government, the focus is on CO_2 and target agreements to improve energy performance. Some Swiss energy performance programs include elements of EnMS but do not explicitly mention EnMS itself.

Thailand

Thailand mandates EnMS for all designated factories and buildings (DFBs) under the Energy Conservation Promotion Act, B.E. 2535. These EnMS are based on Thai standards, which, while not identical to ISO 50001, follow a similar concept to promote energy efficiency and conservation (Energy Conservation Promotion Act, 1992; Wongsapai, 2016; McKane et al., 2017).

The Netherlands

The Netherlands has revised parts of its policy according to the new EED, specifically transposing the law regarding energy data centers. The country still needs to transpose the remaining provisions, which will include mandates for large consumers. The current EnMS policy aligns with former versions of the EED, mandating energy audits for large consumers and exempting companies with ISO 50001 certification.

Turkey

Turkey's eleventh development plan incorporates a promotion program for Energy Management Systems (EnMS). This includes support for Organized Industrial Zones (OIZs) to develop Productivity Action Plans by establishing Energy Management Units and implementing ISO 50001 Energy Management Systems (THE GRAND NATIONAL ASSEMBLY OF TURKEY, 2019).

United Kingdom

The UK's policy on EnMS was originally implemented to fulfill the EED's audit with EnMS requirement. Under the Energy Saving Opportunity Scheme (ESOS) Regulation large companies must conduct an energy audit covering 95% of their total energy consumption or maintain a certified ISO 50001 EnMS. This regulation applies to companies with 250+ employees or significant financial thresholds. Non-compliance can result in fines, even for companies with ISO 50001 certification that fail to file details on time. The ESOS scheme may extend to smaller companies in the future, but no new policy is planned. Additionally, the government provides support for SMEs to adopt ISO 50005, indirectly promoting ISO 50001 standards. Relevant regulations include the ESOS Regulations 2014 and its amendments. The UK is no longer part of the European Union and therefore is not required to transpose the 2023 EED version. (Interview); (McKane et al., 2017; Department for Energy Security and Net Zero, Environment Agency and Department for Business, Energy & Industrial Strategy, 2024).

USA

The United States' approach to EnMS policy stands in stark contrast to the EU's top-down model, embracing a bottom-up strategy that prioritizes voluntary participation and flexibility. The US Department of Energy (DOE) spearheads federal efforts to promote EnMS adoption through a suite of voluntary programs and resources. Two flagship DOE initiatives, the 50,001 Ready and Superior Energy Performance (SEP) 50,001 programs, provide frameworks for organizations to implement and certify ISO 50001-based EnMSs. Numerous state authorities and utilities leverage the DOE programs, integrating them into their policy landscapes through local initiatives and incentive schemes. The US Environmental Protection Agency (EPA) also contributes to this collaborative effort through its Energy Star program, providing additional resources, benchmarking tools, and technical assistance to organizations implementing EnMSs.

The decentralized approach fosters a diverse EnMS policy landscape across the US, with programs tailored to specific regional needs and priorities. Yet, the uptake of federal programs in local programs provides a common framework. The bottom-up strategy aligns with the US emphasis on market-driven solutions and voluntary action, aiming to lower entry barriers and encourage widespread adoption of energy management best practices (Consortium for Energy Efficiency, 2024; U.S. Department of Energy, 2024; Sheaffer et al., 2016; Fuchs et al., 2020; Therkelsen et al., 2015, 2021).

Vietnam

Vietnam's EnMS policies are primarily driven by the Law on Economical and Efficient Use of Energy, which promotes the application of energy management systems, encourages the standardization of energy management systems complying with ISO 50001. Further, the law mandates certification for major users and provides training. In addition to Law on Economical and Efficient Use of Energy, there is the national energy efficiency program. The program promotes ISO 50001 use, supports companies with the implementation and addresses management and decision-makers to support decisions for EnMS.

Appendix C. Question sets

Question set for academic and technical experts

1. Does your country have a policy/regulation/program to encourage the adoption of energy management systems by energy users?
   a. What is the policy's/regulation/program's name?
   b. What is the form of the policy?
      i. Is it a requirement or mandate?
      ii. Is there an encouragement, e.g., a tax reduction? If yes, what is the encouragement?
      iii. Are there penalties for non-conformance?
2. What is your government's motivation regarding EnMS?
   a. Are their EnMS-related activities explicitly linked to decarbonization?
   b. Are they linked to improving energy efficiency/decreasing energy waste?
   c. Other?
3. What is the forecast of what is coming in terms of EnMS related policies, regulations, programs, and other initiatives?
4. Are there any publicly available national metrics on the effects of implementing the policy? How can I access them?
5. Are there any academics or policymakers knowledgeable about energy management systems policies, regulations, programs, and other initiatives in "country" whom you could connect me with?

Question set for policymakers

Q1: Does your country have a policy/regulation/program to encourage the adoption of energy management systems by energy users?
   a. What is the policy's/regulation/program's name?
   b. What is the form of the policy?
      i. Is it a requirement or mandate?
      ii. Is there an encouragement, e.g., a tax reduction? If yes, what is the encouragement?
      iii. Are there penalties for non-conformance?

Q2: What is your government's motivation concerning EnMS?
   a. Are their EnMS-related activities explicitly linked to decarbonization?

b. Are they linked to improving energy efficiency/decreasing energy waste?
c. Other?

Q3: What is the forecast for what is coming in terms of EnMS related policies, regulations, programs, and other initiatives?
Q4: Were there any predictions regarding the effect of implementing the policy?

(a) Number of participants?

a. Level of energy savings, GHG reductions or both?
b. Other?

Q5: Are there any publicly available national metrics on the effects of implementing the policy? How might I access them?

Data availability

The authors do not have permission to share data.

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