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EU-MORE

EUropean MOtor REnovation initiative

Deliverable D2.3 - Co-Created Policy Recommendations for Electric Motor Renovation

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List of Acronyms

Acronym	Definition
AGEFE	Associação de Fabricantes de Equipamentos Elétricos (Portuguese manufacturers' association)
BU	Bottom-Up
CSRD	Corporate Sustainability Reporting Directive
DEEP	De-risking Energy Efficiency Platform
EED	Energy Efficiency Directive
EEffG	Austrian Energy Efficiency Act
EEOS	Energy Efficiency Obligation Schemes
EEW	Federal Funding for Energy and Resource Efficiency in the Economy (Germany)
EIA	Energy Investment Allowance (Netherlands)
EMS	Energy Management Systems
EMSA	Electric Motor Systems Platform
ESCOs	Energy Service Companies
EU-M^3	EU-MORE Motor Model
IRR	Internal Rate of Return
MEPS	Minimum Energy Performance Standards
MIA/VAMIL	Dutch tax incentive schemes (Milieu-investeringsaftrek / Willekeurige afschrijving milieu-investeringen)
NEB	Non-Energy Benefit
NECP	National Energy and Climate Plan
PBT	Payback Time
RVO	Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland)
SGCIE	Management System for Intensive Energy Consumers (Portugal)
SMEs	Small and Medium-sized Enterprises
VAs	Voluntary Agreements
VEKI	Subsidy for Industrial Decarbonization (Netherlands)
VSD	Variable Speed Drives

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1. Executive Summary

The Deliverable *D2.3 - Co-Created Policy Recommendations for Electric Motor Renovation* outlines general and national policy recommendations to accelerate the replacement of inefficient electric motors across Europe. This document builds on previous assessments as described in Deliverable *D2.2 – Motor Policy Review* and incorporates insights gathered from the National Workshops and Co-Creation Workshops organised by the project, along with other significant project results.

The report firstly examines the several barriers slowing down the replacement of old and inefficient electric motors, including high upfront costs, lack of awareness among businesses, behavioural barriers and gaps in regulations that make them fail to encourage the transition to efficient motors.

An analysis of policy instruments that could help overcome these obstacles is then provided. Each instrument is analysed according to its success factors, barriers to implementation, and cost-effectiveness – assessments which are based on past programs and evaluations.

Building on these insights, the report proposes a set of general policy recommendations. A comprehensive approach that combines financial incentives, regulatory requirements, and information campaigns would be the most effective strategy. "Although such an integrated approach would be more resource intensive and time-consuming than individual policy measures, it would result in the highest return on the public investment." . A "stick-and-carrot" approach, which offers incentives for some motor efficiency improvements while enforcing mandatory upgrades for the most outdated systems, could create the intended shift while keeping industry engagement high. The importance of long-term stability in policy frameworks is also emphasized, arguing that efficiency programs should be maintained for at least 10 years to give businesses confidence in making investments. Energy audit programs could be strengthened, for instance by making it mandatory for businesses to report motor inventories and to act on the recommended energy efficiency measures. Additionally, EEOS frameworks could be improved by incorporating specific provisions for motor replacement.

In addition to these general recommendations, the report provides country-specific policy recommendations tailored to the regulatory and market conditions in Austria, Germany, Greece, Portugal, and the Netherlands. Each country section outlines the current policy landscape, identifies key barriers and presents refined recommendations based on stakeholder feedback from National Workshops and Co-Creation Workshops.

2. Introduction

The EUropean MOtor REnovation initiative (EU-MORE) aims to capture the benefits of accelerating the replacement rate of old, inefficient motors through the development of new policies. The project's Work Package 2 focuses on developing policies to accelerate the renovation of inefficient electric motors across the EU. The package involves analyzing the European motor market, reviewing existing policy measures, designing new policies, testing them with stakeholders and integrating circular economy principles into policy development.

The results of the efforts conducted in WP2 have been so far translated into a series of Co-Creation Workshops with national stakeholders and into two reports, namely *D2.1 - European Electric Motor Market Assessment* and *D2.2 - Review of past and existing policies for the acceleration of electric motor renovation*. Both reports can be downloaded from the EU-MORE project website.

The present report, which is building on the assessments conducted in D2.1 and D2.2, provides a structured analysis of the best practices that were identified and a discussion around the opportunities and limitations for motor replacement policies across the EU-MORE partner countries. Subsequently, it provides concrete recommendations for the development of new policies. It also outlines the required resources, the expected impact, and the potential for knowledge transfer and implementation.

The report also relies on the results achieved in other project activities, namely the Co-Creation Workshops (WP2), the Modelling and Projection of policy impacts (WP4) and the National Workshops (WP5). All these activities have provided fundamental input to this report, in the form of structured feedback about policy recommendations from the consulted stakeholders (policymakers, policy experts, industrial stakeholders, energy consultants, ESCOs) and of impact assessments of modelled policies.

3. Methodology

The methodology adopted for the development of policy recommendations consisted in a series of preparatory activities:

1. **A motor market analysis**, to assess the improvement potential at EU level
2. **An analysis of motor system efficiency trends**, to assess the improvement potential at motor level
3. **An assessment of potential non-energy benefits (NEBs)** of early motor replacement
4. **A motor policy review**, to map the landscape of past and existing policy measures in the EU that directly or indirectly stimulate(d) motor replacement, including the identification of success factors and shortcomings
5. **The development of a model to assess the impact** on energy use, GHG emissions and material use of potential motor replacement policies
6. **Interaction with stakeholders** though National and Co-creation Workshops, to ensure that recommendations are anchored in the reality in the field and supported by a broad basis

1. A motor market analysis

In the early stage of the project, a motor market analysis (Deliverable D2.1) was conducted to assess the number and the characteristics (efficiency, nominal power, load, operating hours) of the electric motors populating the European market. The market analysis highlighted the discrepancy between the derived

figures of motor electricity consumption among diverse data sources, underscoring the **need to have accurate and recent data on motor sales and on the characteristics of the installed base, including average motor lifetimes, motor loads and operating hours**. The report also highlights how the 88% of motors that fall within the scope of the Ecodesign regulation are sold with an energy efficiency level of IE3 or higher, which is evidence of the regulation effectiveness.

2. **An analysis of motor system efficiency trends**

The analysis of motor system efficiency trends conducted in EU-MORE Task 4.1 (Deliverable D4.1) compares different motor types in terms of cost, efficiency and suitability for different applications, providing a knowledge base to identify priority areas for incentives, regulations or other motor replacement policies. In general, the report serves as a strong foundation for designing effective motor replacement policies by providing **data-driven insights into motor efficiency trends, system optimization, digitalization opportunities and barriers to adoption**.

3. **An assessment of potential non-energy benefits (NEBs)**

The assessment of the Non-Energy Benefits (NEBs) of motor replacement in Task 4.3 has emphasized the need to expand existing policies to consider NEBs such as operational reliability, reduced maintenance costs, increased worker safety, lower noise and vibration levels and improved industrial productivity. Policies that incorporate NEBs into cost-benefit analyses can indeed make the case for motor replacement more compelling to businesses (Participant perspective) and policymakers (Utility and Society perspectives).

4. **A motor policy review**,

In parallel, the motor policy review (Deliverable D2.2) analysed the motor policy landscape across the EU and at international level, providing a comprehensive repository of policy measures targeting motors or broader energy-efficiency measures. The review highlighted how the policies implemented so far have primarily addressed financial barriers to motor replacement and consist mostly in subsidy programs or tax incentives. **The need to address behavioural and knowledge barriers** was underscored, putting particular emphasis on the need to promote training programs, information campaigns and capacity building, along with a **system approach to motor replacement** able to achieve greater electricity savings. The policy review also provided a series of best practices from EU Member States more active in policies supporting motor replacement.

5. **The development of a model to assess the impact**

The analysis of policy impacts in Task 4.2 has served as a crucial reference for designing effective motor replacement policies. The activity has resulted in the development of the EU-M^3 Motor Model, a tool designed to measure **the impact of motor replacement policies** on energy consumption, greenhouse gas (GHG) emissions and raw materials. The tool enables policymakers to conduct scenario-based analyses, helping them predict the effectiveness of financial and non-financial policies before implementation, combining data-driven modelling, real-world policy case studies and cost-effectiveness analysis.

6. **Interaction with stakeholders**

The interaction with a broad range of stakeholders has been pivotal for the development of general and national policy recommendations. The collection of feedback from companies, manufacturers, ESCOs, energy advisors and policy experts has been conducted through 11 National Workshops implemented in Greece, Austria, Germany, Belgium, the Netherlands and Portugal. These workshops permitted to gather insights on the barriers and opportunities of motor replacement from several different perspectives, often overlooked in top-down policy approaches. Such insights have been crucial for the development of the

general EU-MORE policy recommendations, meant to capture the common aspects surrounding the replacement of electric motors across the EU.

In parallel with the National Workshops, 5 Co-Creation workshops have been implemented in Greece, Austria, Germany, Netherlands and Portugal in order to discuss the tailored national policy recommendations with national authorities, energy agencies, policy experts and policymakers. The relevant stakeholders, in this context, provided specific feedback about the relevance, opportunities and possible shortcomings of the proposed policies. The present report aims to provide a complete overview of the policy development process by presenting the first policy recommendations, the feedback gathered from the stakeholders and the final derived recommendations incorporating such feedback. In Table 1: Co-creation workshops implemented by EU-MORE a summary of the implemented Co-Creation workshops is reported.

Member State covered	Date	Stakeholders involved
Austria	27.08.2024	Ministry, Governmental agency, Energy agency
Portugal	27.11.2024	Energy agency, industry association, industrial companies, motor manufacturers
Greece	19.11.2024	Ministry, municipal companies, financial institutions, regional authorities
Netherlands	09.12.2024	Enterprise agency (Ministry's executive body)
Germany	03.12.2024	Ministry, funding authority, national energy agency, regional energy agency, research institutions

Table 1: Co-creation workshops implemented by EU-MORE

The responses collected in the National and Co-creation workshops, along with the developed policy recommendations, have been shared on the EU-MORE Multi-Stakeholder Platform and Motor Policy Forum to foster discussion around the technical and policy aspects of motor replacement.

4. Analysis

4.1 Barriers to the replacement of old, inefficient electric motors

In 2015, electric motor systems accounted for 53% of global electricity consumption, amounting to 10,700 TWh and contributing to 5.5 Gt of CO_2-equivalent emissions. By 2020, electric motors represented approximately 70% (650 TWh/year) of industrial electricity consumption within the EU27 and over 40% (255 TWh/year) of electricity consumption in the service sector.

Rising awareness among policymakers, manufacturers and industry end-users regarding the scale of energy consumption and associated emissions has driven the introduction of minimum energy efficiency regulations and the development of energy-efficient technologies to meet and surpass these standards.

Accelerating motor replacement across the EU could unlock annual energy savings of up to 25 TWh. When entire motor systems are modernized—not just the motors themselves—the savings potential increases significantly, ranging from 73 to 133 TWh per year, equivalent to the entire electricity consumption of the

Netherlands. In addition to energy savings, optimizing motor systems can offer significant non-energy benefits, such as increased reliability, reduced maintenance costs and enhanced system performance[1].

The payback periods for investments in energy-efficient motor systems are relatively short, making motor replacement a financially attractive decision. According to the De-risking Energy Efficiency Platform (DEEP), the median payback time for energy-efficient motor projects in the EU27 is less than two years for large enterprises and 4.5 years for small enterprises, with median avoided costs of 4.63 euro cents per kWh[2].

Despite these advantages, the adoption of highly efficient motor technologies remains slower than expected. Motors often remain in service longer than anticipated, escaping the scope of existing regulations. An analysis conducted by the AUDIT2MEASURE project identified multiple factors hindering investments in high-efficiency cross-cutting equipment (motors, drives, pumps, HVAC systems, lighting)[3]. These include uncertainties regarding future energy prices and technological advancements, as well as secondary factors like excessive time investment and limited technical expertise.

Almeida (1998) highlighted how procurement processes in large firms often reveal structural barriers. For instance, the department responsible for purchasing new motors is typically separate from the one managing electricity expenses. In smaller companies, motor breakdowns are treated as emergencies and replacement speed takes priority over energy efficiency considerations. Many companies also stock backup motors of the same type to ensure rapid replacement in case of failure.

Investment decisions are frequently driven by initial purchase costs, while operational costs—which account for most a motor's lifetime expenses—are overlooked. The typical price premium of 20% to 30% for high-efficiency motors can prevent companies from opting for more efficient options (Almeida et al., 2008). Furthermore, the expertise and capacity of employees play a crucial role in system optimization. Finding experts in motor system optimization is particularly challenging (Nadel et al., 2002).

The availability of high-efficiency equipment at reasonable prices is another prerequisite for investment. However, in developing countries, such equipment is often not produced locally and must be imported at relatively high costs. Moreover, electric motor-driven systems, such as compressed air, pumps and ventilation, are often viewed as auxiliary systems, falling outside the primary focus of decision-makers (UNIDO, 2011).

Groot et al. (2001) categorized barriers to new technology adoption into three levels:

- **Decision-making process:** Prioritization of core production activities and alternative investment opportunities over energy efficiency.
- **Financial constraints:** Budget limitations that restrict capital allocation for energy-efficiency projects.
- **Future uncertainties:** Concerns about fluctuating energy prices, evolving technologies, policy changes and the reliability of new solutions.

Not all recommended energy efficiency projects that involve industrial motor systems are implemented. A study of U.S. manufacturing plants found that only about half of the suggested projects were adopted. Anderson and Newell (2004) identified the primary reasons for non-adoption, including:

[1] EU-MORE Deliverable D4.4 - Report on non-energy benefits in electric motors
[2] https://deep.ec.europa.eu/viewcharts/industry/?country=EU27. The median payback period is calculated on a sample of 553 companies, while the median avoided costs on a sample of 1264 companies.
[3] https://ieecp.org/wp-content/uploads/2023/09/A2M_D2.3_Barriers-uptake-ESM.pdf

- High initial costs;
- Insufficient staff for project analysis or implementation;
- Limited cash flow;
- Unsatisfactory return on investment.

Projects with shorter payback periods, lower upfront costs, higher annual savings and greater energy conservation tend to have higher adoption rates. According to Anderson and Newell (2004), firms are more sensitive to upfront investment costs than to potential energy savings. Given that industrial facilities often operate dozens or even hundreds of motors, measures supporting a project prioritization based on company interests can facilitate more effective replacement strategies.

A further challenge lies in the lack of information or reliable measurements regarding potential energy savings (Rohdin and Thollander, 2006). Robust decision-support tools can play a pivotal role in overcoming this barrier, empowering companies to make informed investment choices.

Through national workshops, EU-MORE gathered valuable feedback and insights from industrial stakeholders regarding the specific barriers to replacing inefficient motors. Stakeholders highlighted that motor replacement can lead to non-energy-related challenges, such as disruptions to critical industrial processes or the need to modify existing spaces to accommodate larger, more efficient motors. Additionally, the composition of a company's motor stock plays a pivotal role in replacement decisions. Many stakeholders noted that older, less efficient motors from existing stock are often favored for replacing failed units due to their faster installation and lower associated costs.

4.2 Available Policy Instruments to Foster Motor Replacement

According to the EU-MORE policy review conducted in D2.2, EU Member States generally lack targeted policies for replacing old and inefficient electric motors, despite their substantial contribution to industrial energy consumption and carbon emissions. Existing policy instruments promoting energy efficiency are typically broad and sector-wide, failing to specifically address motor replacement. Given that motors account for more than half of industrial electricity consumption, the introduction of dedicated policies is essential to achieving national energy-saving targets.

To align with the National Energy and Climate Plans (NECPs) and the Energy Efficiency Directive (EED)—particularly Articles 7, 8 and 11—Member States must implement policies that promote energy efficiency. However, as many continue to fall short of their targets, there is an urgent need for stronger, motor-specific interventions.

Effective policies should both mandate and incentivize early motor replacement while encouraging technological advancements, such as digitization, Variable Speed Drives (VSDs) and higher efficiency standards. Investing in capacity-building and training programs is crucial to equip motor operators, energy experts and auditors with the skills needed for thorough system assessment and optimization.

Apart from stimulating the replacement of old and inefficient motors, motor policies should also support the transition to a more circular economy, e.g. through enhanced recycling processes for old motors. At first, circular economy strategy and replacement if older motors may seem contradictory, as the first may also aim at long lifetimes. However, given that most of the energy use of a motor occurs while being used, increased energy use for the production of the new motors replacing the old ones will be compensated

quickly, in particular when efficient motor recycling supports this strategy and when the faster replacement strategy is limited in time.I More details about this can be found in D.2.4 - A*nalysis of end-of-life practice for motors.*

This section analyzes the policy instruments available to promote the replacement of inefficient electric motors, assessing their suitability for the proposed policy recommendations. Each instrument is evaluated based on its **success factors, barriers and cost-effectiveness.** A similar analysis was conducted in EU-MORE's Deliverable D4.3 – *Policy Impact Analysis*, which examined selected policy instruments modeled using the EU-MORE Motor Model (EU-M^3). This report takes a broader perspective, incorporating all the categories of policy instruments analyzed in Deliverable D2.2.

Energy audits and capacity building programmes

To unlock the significant energy-saving potential of optimizing entire motor systems, rather than focusing solely on individual high-efficiency components, a plant-by-plant approach is essential. Industrial plants vary widely, as do their compressed air, pump and fan systems. Effective system optimization requires detailed assessments tailored to each facility and must be closely linked to a firm's capacity development and energy management practices. Various policy options have been proposed and implemented worldwide to address motor system optimization from a system-level perspective, with energy audit schemes being one of the most prominent measures.

Energy audits have been implemented in many countries, but differ in design and scope, and in the way they are integrated into broader energy efficiency policies. They can be mandatory, requiring audits at specified intervals, or voluntary, often incentivized through subsidies. Audits range from basic "walk-through" assessments to comprehensive evaluations, with many countries adopting a combination of both. Successful audit programs are often supported by complementary policies, such as training qualified auditors, setting corporate energy efficiency goals and providing financial support for energy-saving investments (UNIDO, 2011). These audits are among the most cost-effective government initiatives, ensuring that optimal energy efficiency measures are identified by assessing entire motor systems, not just individual components (De Keulenaer, 2004).

A prime example is China's Motor Systems Energy Conservation Program, implemented by UNIDO between 2001 and 2004 in the Jiangsu and Shanghai provinces. This pilot program aimed to build capacity for motor system optimization through expert training and plant-level energy audits. Two groups were trained: factory personnel and external experts. The latter continued working in two energy centres established as part of the program, offering ongoing audits and training. The program trained 22 system optimization experts and conducted 38 plant assessments, revealing an annual savings potential of 40 GWh—approximately 23% of system electricity consumption. Most proposed energy efficiency investments had short payback periods of one to two years. Additionally, over 10 demonstration projects were implemented and nearly 1,000 factory personnel were trained, achieving significant energy efficiency improvements across multiple companies.

Similarly, Brazil's Industrial Energy Efficiency Program, launched in 2003, initially focused on optimizing existing motor systems, accelerating the adoption of high-efficiency motors and enhancing technical support. The program emphasized capacity development, involving the National Confederation of Industry in its design and implementation. In its first phase, university teachers and consultants underwent a 176-hour motor system optimization course. These trained "multipliers" then trained industry staff to conduct energy audits within their own companies. By 2005, 766 companies had participated, training 906 representatives to conduct 1,140 audits. A total of 123 multipliers from universities and consultancies facilitated the training.

Lessons to be learned from this program include the need for more practical, hands-on training and for greater emphasis on system-wide optimization rather than just motor replacement.

Germany adopted a different approach, introducing an Energy Efficiency Fund in 2008 to support small and medium-sized enterprises (SMEs). The fund combined subsidized energy audits with low-interest loans for efficiency investments, addressing common barriers such as limited capital and insufficient internal expertise. While not exclusively focused on motor systems, many recommended and implemented projects involved motor system optimization.

In Austria, the klimaaktiv program, managed by the Austrian Energy Agency under the Federal Ministry for Climate Action (BMK), promotes energy efficiency and renewable energy adoption across sectors, with a significant focus on energy audits and capacity building. The Energy Efficiency Law in Austria mandates energy audits as a core strategy for improving industrial energy efficiency. Large companies must either conduct external energy audits every four years or implement an energy management system (EMS). Auditors performing these assessments must meet strict qualification standards and be listed in a public register. The klimaaktiv program has developed audit guides for motor-driven systems, including pumps, fans, chillers and compressed air systems, that can be used for the official audits. These guides detail energy-saving measures, calculation methodologies and data collection protocols for quick on-site evaluations. Standardized reporting formats ensure consistent documentation across audits. Capacity building is a central component of klimaaktiv, targeting both internal company staff and external energy consultants. The program offers training and webinars, certifications, technology-specific trainings (such as the 2022 pump training and 2023 fan training, using the EMSA motor systems tool for precise motor replacement calculations) and knowledge resources. Since its inception, klimaaktiv has trained over 550 consultants and supported 200 companies in implementing energy efficiency measures. The program also facilitates networking among businesses, energy consultants and technology providers

Success factors

Financial policy measures are typically the most favored approach for promoting energy efficiency. To maximize their impact, they should be complemented by energy audits and training initiatives for energy managers.
These can act as catalysts for unlocking investment potential within industrial SMEs by identifying areas of energy waste and guiding the specification of efficient solutions.
However, financing energy efficiency projects presents unique challenges, such as the fact that benefits are realized as cost savings rather than direct revenues and that savings can be difficult to quantify without established measurement and monitoring protocols.

To overcome these challenges, energy audits and the implementation of Energy Management Systems (EMS) are essential prerequisites for successful financing programs. They enable policymakers to accurately assess energy efficiency gains and the cost-effectiveness of proposed measures.
Clear and concise information provided by Member States can further reduce barriers, such as limited awareness of benefits and available support schemes, or concerns about hidden costs. Increasing industry knowledge and awareness can significantly improve implementation rates.
A crucial lever for enhancing implementation is the stronger alignment between the measures identified in energy audits and the corresponding funding programs available for their execution. Auditors should be encouraged to highlight appropriate funding opportunities and provide links to cost estimation tools, such as those available on the *klimaaktiv* program website, along with best-practice examples from companies that have successfully adopted similar solutions. To support this, the national energy efficiency monitoring body could enrich its website with industry-specific case studies, including experience reports from business owners (D2.2 – Austria).

A notable example of best practice comes from Belgium, where energy audits are mandatory for large companies and major energy-consuming facilities seeking environmental permits. The audit must be conducted by an accredited auditor, who collaborates with the building operator to develop an action plan outlining recommended measures along with a timeline for implementation. The most impactful aspect of this program is that licensees are required to implement energy audit measures with a payback period of less than five years. This ensures that cost-effective solutions identified through the audit contribute directly to energy savings and greenhouse gas emission reductions (D2.2 – Belgium).

Given that the payback period for new, efficient electric motor systems generally falls below five years, such programs could significantly accelerate the replacement of outdated motor systems across the industrial sector.

Barriers

Energy audits and EMS play a vital role in identifying energy efficiency opportunities, yet significant barriers impede the implementation of recommended measures.

A critical challenge lies in skill gaps across the supply chain. Europe faces a shortage of qualified energy auditors and project developers with specialized expertise in industrial process engineering, leading to overlooked opportunities in process optimization and heating systems. Compounding this issue is the lack of marketing and financial literacy among auditors, hindering their ability to design compelling business cases or secure funding for projects. At the regulatory level, the EU lacks robust mechanisms to enforce the execution of audit recommendations (Raimondi et al., 2018). This policy gap allows inaction to persist, even when efficiencies are identified.

Further obstacles arise at the corporate level: many companies remain unaware of the long-term benefits of energy efficiency, lack familiarity with support schemes, and fear hidden costs (D2.2 – Austria).

To bridge these gaps, an integrated approach is essential, including targeted training programs for auditors, stronger EU mandates to prioritize audit implementation, and awareness campaigns to highlight energy efficiency benefits and financial tools.

Cost effectiveness

Energy audits are widely recognized as one of the most cost-effective tools for enhancing industrial energy efficiency, particularly since they are often tied to mandatory legislative frameworks that eliminate the need for additional government funding. A programme in Cyprus is an exception to this rule, as it subsidizes audit costs to stimulate energy interventions in industry. Under this initiative, SMEs receive public funding covering 30% of the audit cost, capped at €2,000 per company. Participating SMEs are further expected to implement the energy-saving measures identified in their audits by leveraging private funds, financial instruments, or partnerships with licensed Energy Service Providers (D2.2 – Cyprus).

Danish data reveal differences in cost-benefit ratios based on company size. For firms with an annual energy consumption below 2 GWh, average figures of audit expenses nearly match those of potential first-year savings. Mid-sized companies (2–20 GWh/year) see a more favorable ratio, with audit costs representing just 20% of first-year savings. When going further up in company size, the picture changes again, with the largest energy consumers (exceeding 20 GWh/year) facing disproportionately higher relative costs, and their audits accounting for 60% of projected savings on average.

This disparity, as highlighted in D2.2 – *Denmark*, likely stems from the complexity of the energy systems and operational processes at larger enterprises, coupled with their prior investments in energy-saving initiatives. These two factors make easy-to-achieve energy efficiency gains ("low-hanging fruit") scarcer,

resulting in audits being more resource-intensive and less immediately cost-effective compared to those at smaller firms. The findings underscore the need for tailored strategies that account for company size and pre-existing energy management practices to maximize audit effectiveness.

Mandatory requirements - Energy Efficiency Obligation Schemes (EEOS)

Energy Efficiency Obligation Schemes (EEOSs) are regulatory frameworks that legally require energy utilities (e.g., electricity, gas, or district heating providers) to achieve a defined amount of energy savings by implementing energy efficiency measures across end-users in the residential, commercial, industrial, transport, and heating sectors. These obligations, enforced by governments through formal monitoring and verification processes (Bertoldi et al., 2010), incentivize utilities to invest in cost-effective energy-saving initiatives while shifting financial responsibility away from public budgets. By promoting efficiency upgrades like insulation, efficient appliances, or industrial retrofits, EEOSs stimulate market innovation and reduce long-term energy demand.

A complementary mechanism, the white certificate system, transforms these obligations into tradable instruments, creating a dynamic market where utilities or energy service companies (ESCOs) can buy, sell, or trade certificates to meet their targets. This market-based approach encourages utilities to pursue the most cost-effective saving measures, covering their investment and transaction costs while fostering cross-sector collaboration. It is similar to green certificate systems and to the EU Emissions Trading Scheme. Such flexibility enhances private-sector engagement, positioning EEOSs as a "win-win" for governments, utilities, and consumers.

The French White Certificates Scheme is particularly interesting for the replacement of electric motors as its official catalogue of efficiency measures includes standardised actions related to electric motors, such as the installation of an IE4 asynchronous motor, the installation of a VSD on an asynchronous motor, the installation of a permanent magnet or synchronous reluctance motor with VSD, and the installation of an electronic control system for an electric motor with energy recovery[4].

The Italian White Certificates Scheme also includes the installation of high efficiency motors as a standardized project, i.e. a standardized procedure is provided by the managing authority GSE to compute the electricity savings resulting from motor replacement[5].

While EEOSs avoid direct government expenditure, their costs fall into four categories:

1. **Programme costs**: Expenses sustained by obligated parties, including grants to customers (e.g., partial funding for insulation), administrative overheads, marketing and contractor fees.
2. **Societal costs**: Total investment in energy efficiency measures, combining utility contributions (e.g., €500 rebates) and customer co-funding (e.g., €1,000 for a €1,500 retrofit).
3. **Administrative costs**: Regulator expenses for oversight, verification and reporting.
4. **Start-up costs**: One-time setup fees for designing schemes, training staff, and stakeholder consultations.

[4] Opérations standardisées d'économies d'énergie | Ministères Aménagement du territoire Transition écologique
[5] https://www.gse.it/servizi-per-te_site/efficienza-energetica_site/certificati-bianchi_site/presentare-progetti_site/Documents/Tabella%20Tipologia%20Intervento%20ps.pdf

Costs vary significantly by country, ranging from €185 million annually in Denmark to over €1 billion/year in the UK, influenced by market size, policy ambition and synergies with other instruments. For instance, France's EEOS costs are reduced by allowing households to combine EEOS funds with tax rebates (*Crédit d'Impôt Transition Energétique*), lowering the burden on utilities.

Despite these expenses, EEOSs demonstrate exceptional cost-effectiveness: the average cost to utilities per saved kWh in Europe is 0.4–1.1 euro cents (Rosenow and Bayer, 2016), far below the marginal cost of energy production. This efficiency, coupled with long-term energy demand reduction and emissions savings, underscores their value as a pillar policy for accelerating the clean energy transition.

EEOSs are well-suited to address the barriers hindering electric motor replacements, particularly the high upfront costs and split incentives that often deter industrial and commercial users from adopting more efficient models. EEOSs require obligated utilities or ESCOs to fund rebates, grants, or subsidized loans for motor replacements, reducing the payback period for end-users. For example, a utility could cover 30–50% of the motor's cost via EEOS-funded programmes, leveraging societal cost-sharing (e.g., the customer pays the remainder). In the case of white certificates, utilities can monetize energy savings from motor replacements by them. For instance, a utility investing in motor retrofits for factories could generate certificates equivalent to the kWh saved, selling them to other obligated parties struggling to meet targets. This creates a self-sustaining market, where transaction costs and risks are distributed across participants, making large-scale motor replacement programmes viable.

In overcoming split incentives, EEOSs can mandate "landlord-tenant" collaboration models, where utilities facilitate agreements to share savings between parties (e.g., via split-incentives contracts). Alternatively, utilities might directly fund replacements in multi-tenant industrial parks, recovering costs through white certificate revenues.

Success factors

Greece's Energy Efficiency Obligation Scheme (EEOS) has emerged as a notable success story, with reported energy savings surpassing initial targets by a significant margin, as highlighted in *D2.2 - Greece*. A series of factors determining the success of EEOSs could be identified:

- **Collaborative governance**: A key success factor was the establishment of clear, consensus-driven methodologies for implementation, fostered through proactive communication and alignment between all stakeholders—including implementing authorities and obligated parties. This collaborative approach minimized conflicts and ensured unified progress toward shared goals.
    - **Robust framework: transparent targets and roles**: The scheme's clarity in defining obligations (e.g., obligated parties, beneficiaries) and quantifiable energy-saving targets provided a strong foundation for accountability.
    - **Cost-Effective Monitoring and Verification (M&V)**: A standardized M&V methodology balanced accuracy with simplicity, reducing administrative burdens while maintaining rigorous oversight of declared savings. This optimized both compliance costs for obligated parties and the scheme's overall cost-effectiveness.
- **Market innovation via White Certificates**: While most EEOSs globally have yet to fully embrace trading mechanisms, Greece's scheme is positioned to integrate a **white certificate system**—a move widely advocated by experts. Such a system could amplify savings by fostering competition and transparency among participants (e.g., utilities, ESCOs). Though introducing trading adds complexity, the potential benefits—including diversified funding streams, incentivized innovation and reduced compliance costs through market flexibility—far outweigh these challenges.
- **Regulatory control**: Strong, transparent regulation ensured rigorous oversight of the scheme's operations and claims of savings, bolstering stakeholder confidence and preventing misuse.

Barriers

Energy companies traditionally profit from selling more energy, creating a fundamental conflict with energy efficiency goals[6]. This misaligned incentive can lead to superficial compliance, with utilities prioritizing low-impact measures, such as public awareness campaigns, over high-cost, high-savings projects like industrial motor replacements—a pattern observed in EEOS implementations across Europe. Similarly, obligated parties often favor measures with the lowest upfront costs, such as eco-driving training courses or informational campaigns, to meet targets cost-efficiently – an approach that risks neglecting transformative investments, like replacing outdated motors, which yield greater long-term savings but require higher initial expenditure.

Cost effectiveness

Energy Efficiency Obligation Schemes (EEOS) are widely recognized as cost-effective policies, as the costs incurred by obligated parties to meet energy savings targets are typically far lower than the societal costs of energy production (Rosenow & Bayer, 2016). Administrative and start-up costs, while present, constitute only a minor fraction of total EEOS expenditures. Compared to traditional grant programs, obligations reduce overall costs to achieve efficiency targets by leveraging market-driven compliance. However, cost transparency remains a challenge: data are rarely published, inconsistently reported, and difficult to compare across EU Member States. Programme costs (e.g., subsidies, rebates) are more commonly disclosed, while administrative costs (e.g., scheme setup, monitoring) and participant costs (e.g., end-user investments) are seldom quantified, often requiring *ex-post* evaluations. This inconsistency in reporting—coupled with variations in policy design—hampers cross-national comparisons of EEOS cost-effectiveness.

Available data suggest that obligated parties' costs typically range between **4–11 €/MWh**, aligning with figures reported in the ENSMOV project factsheets (ENSMOV, 2021):

- **Denmark (2016–2017):** 6–7 €/MWh (10-year savings lifetime).
- **France:** 6.7–8 €/MWh (based on recent market prices).
- **Ireland (2016):** 56 €/MWh (first-year savings only).

A 2021 study of 35 EEOSs and two energy efficiency auctions found an average weighted programme cost of **€0.011 per kWh** of lifetime energy savings, with similar results in major EU schemes (Austria, Denmark, France, Italy and the UK). For Greece and Ireland, 2017–2018 data show average costs of **0.04–0.06 €/kWh** based on first-year savings. When calculated over a 10-year horizon, this drops to **0.004–0.006 €/kWh**, consistent with long-term savings trends in other countries (ENSMOV, 2021). These figures underscore EEOSs' economic viability, particularly when accounting for persistent energy price volatility.

Concerning White Certificates, these schemes are funded by obligated parties, such as energy suppliers, who recover costs through energy bills. This places the financial burden on energy consumers rather than taxpayers, as would occur with publicly funded initiatives (D2.2).

In Italy, ex-post evaluations of energy efficiency projects revealed a cost-effectiveness of **0.017 €/kWh**—seven times lower than the average cost of tax deductions (Malinauskaite et al., 2019). Alternative measures, such as tax relief (0.98 Mtoe/year since 2014) and the thermal energy account (1.47 Mtoe/year since 2014), are projected to achieve combined annual savings of **1.38 Mtoe**. Industry accounts for most of the White Certificate-driven savings, contributing **5.1 Mtoe** of the total **5.5 Mtoe/year**.

[6] https://www.europarl.europa.eu/RegData/etudes/etudes/join/2010/451482/IPOL-ITRE_ET%282010%29451482_EN.pdf

These schemes require energy companies to promote efficiency through mechanisms like tradable energy savings. A unified analysis of programs in the UK (2002), Italy (2005) and France (2006) found "negawatt-hour" costs of **€0.009/kWh** (UK) and **€0.037/kWh** (France)—both below national energy prices. Benefits such as reduced bills and CO_2 savings outweigh implementation costs, rendering the schemes self-financing and economically efficient (Malinauskaite et al., 2019).

Grants & Subsidies

Success factors

The success of grants and subsidy programs for accelerating motor replacement hinges on several interconnected factors. Clear eligibility criteria, such as targeting motors older than 15 years or end-users with high electricity consumption, ensure focused impact. Transparency in funding structures—like specifying subsidy rates tied to motor size or efficiency gains—helps avoid market distortions while incentivizing upgrades.

Simplicity in program design, from straightforward application processes to unambiguous rules, enhances accessibility, particularly for SMEs. Program duration must be balanced: long enough to allow market actors to adapt, but short enough to prevent prolonged price distortions. Engaging stakeholders—manufacturers, distributors, industry groups and policymakers—during design phases fosters alignment and trust.

Robust monitoring mechanisms, including third-party verification and public reporting, validate outcomes and maintain accountability. To minimize free-riders, programs often cap subsidy rates (e.g., 30–50%) and focus on investments with longer payback periods (>3–4 years). Environmental alignment, such as recycling mandates for old motors or tracking material flows (e.g., copper in high-efficiency models), adds sustainability depth. Case studies illustrate these principles: Portugal's PPEC combined 51% subsidies with technical assessments and recycling incentives, Switzerland's ProKilowatt prioritized cost-effectiveness through competitive tenders and 30% caps, and India's NMRP drove adoption via bulk procurement, financing options and awareness-raising campaigns (EU-MORE Deliverable D2.2).

Barriers

Barriers to grants and subsidy programs include budgetary constraints, as limited public funds often restrict the scale and reach of subsidy schemes, making it difficult to meet demand or incentivize widespread adoption. Dependency on profitability also poses a challenge, as tax incentives like rebates require companies to generate profits, excluding loss-making SMEs or industries in financial distress.
There is also the risk of "free riding", meaning that subsidies reward companies for investments they would have made regardless, reducing additionality and wasting public resources. Organizational resistance, such as internal barriers, competing priorities, or lack of managerial focus on energy efficiency, can further hinder uptake even when subsidies are available.
Market distortions may arise if subsidy rates are excessively high or programs run too long, inflating product costs and reducing competition. Additionally, complexity and administrative burdens from complicated eligibility criteria, application processes, or reporting requirements often deter participation, especially among resource-limited SMEs.

Data limitations, such as inaccurate or outdated information on motor stock, lifetimes, or efficiency levels, undermine the precision of subsidy targeting and impact assessments. Static assumptions in modelling, including simplified estimates of motor lifetimes or efficiency gains, may lead to overly conservative or misaligned policy designs.
Rebound effects can further dilute environmental benefits, as energy savings from subsidies might be offset by increased production or usage elsewhere. Poor communication also leads to a lack of awareness,

preventing target audiences, particularly SMEs (Trianni et al., 2016), from accessing subsidy opportunities or technical support.
Material and recycling challenges emerge with early replacement policies, which can increase demand for raw materials, like copper in high-efficiency motors, without adequate recycling infrastructure, raising sustainability concerns.
Finally, measurement and verification difficulties complicate tracking actual energy savings and ensuring compliance with subsidy terms, as robust monitoring systems can be resource-intensive to implement.

Cost effectiveness

Financial policies, such as subsidies and tax incentives, typically achieve cost-effectiveness in the range of 0.01–0.10€ of public subsidy per kWh saved over the equipment's lifetime. For example, the Dutch Energy Investment Allowance (EIA) reported a cost of 14€ per tonne of CO_2 saved, rising to 21–46€/tCO_2 when accounting for free-riders. Key factors influencing effectiveness include subsidy rates – with higher rates (e.g., 30–50% of motor costs) improving the uptake but increasing the risk of free-riders and market distortions -, as well as targeted efficiency gains, with the replacement of low-efficiency motors (IE1/IE2) by premium classes (IE4/IE5) yielding greater savings. Program design also plays a role, with competitive tenders like Switzerland's ProKilowatt programme stimulating cost-effectiveness.

Case studies highlight diverse outcomes: Portugal's PPEC subsidized 51% of motor costs, achieving 0.008€/kWh saved (115 GWh saved, 43 ktCO_2eq reduced); Switzerland's ProKilowatt capped subsidies at 30%, resulting in 0.03€/kWh saved (14.5 TWh saved from 2010 to 2023); and the Netherlands' EIA provided tax rebates with a 9.1% effective subsidy rate, yielding 0.019€/kgCO_2eq saved. Non-financial policies, such as information campaigns, show an estimated cost-effectiveness of 0.005–0.015€/kWh saved, though reliability remains low due to variable design and scalability challenges, as seen in Austria's *klimaaktiv* program, which trained over 1,000 consultants but faced challenges in quantifying impact.

Information / Awareness raising

Success factors

The **Ökobusiness Vienna Programme** stands out as one of the most successful policy measures in this category, achieving broad adoption through strategic design choices (for full details, see *D2.2*). Its effectiveness stems from a low-threshold entry model: companies receive an initial 8-hour consultancy session paired with high subsidy rates, lowering barriers to participation. Transparency and accountability are prioritized through a public database tracking implemented measures, while standardized reporting templates ensure consistency and quality in audit outputs.

The programme's modular structure caters to diverse business needs: **ÖkoBonus** supports smaller SMEs in launching basic environmental actions, **ÖKOWIN** engages larger corporations in deeper sustainability efforts and specialized streams like the *Eco-label Tourism* module target sector-specific challenges. Annual evaluations of both the overall programme and individual modules—published in detailed reports—secure ongoing funding and enable iterative refinements.

Complementing these features are **implementation support mechanisms**, including parallel programmes for technical assistance and a focus on recognition: companies excelling in sustainability practices receive awards, while their success stories are showcased online to inspire broader adoption. Together, these elements create a virtuous cycle of engagement, accountability and visible impact.

Barriers

Implementing national or regional programmes to raise awareness and disseminate information on industrial energy efficiency faces several systemic and contextual challenges. A primary barrier is limited engagement from industries, often stemming from a lack of perceived urgency or prioritization of energy efficiency. Many companies, particularly SMEs, operate under short-term financial pressures, viewing efficiency upgrades as non-essential investments rather than strategic opportunities.
In the specific case of the **Ökobusiness Vienna Programme**, the difficulty in reaching micro SMEs was observed, due to the frequency of rented facilities and flat-rate utility bills (LEAP4SME, 2022).
This is strengthened by insufficient trust between policymakers and industry, especially in regions with historically adversarial government-business relationships, where companies may dismiss programmes as bureaucratic intrusions rather than collaborative tools.

Information overload or misalignment further undermines effectiveness. Programmes often provide generic, overly technical content that fails to resonate with specific sectors (e.g., steel vs. textiles) or address unique operational realities. Without tailored messaging, businesses struggle to connect abstract efficiency concepts to their bottom line. Similarly, poor communication channels—relying on outdated platforms or lacking direct engagement with decision-makers—limit reach. For instance, workshops targeting mid-level managers may fail to influence executives who control the company's budgets.
Financial and structural constraints also play a role. Many programmes lack funding for sustained outreach, leading to sporadic campaigns that fade before changing organizational cultures.

Additionally, industries in regions with limited access to financing may dismiss efficiency measures altogether, even when aware of benefits, due to high upfront costs. The "split incentive" problem exacerbates this: in leased industrial facilities, building owners have little motivation to invest in upgrades if tenants pay energy bills.

Institutional fragmentation within governments—such as misaligned priorities between energy, environment and industry ministries—can dilute programme coherence. Bureaucratic delays in launching initiatives or revising outdated regulations (e.g., permitting processes) also stall momentum. Meanwhile, lack of standardized metrics to quantify programme impacts—such as energy saved per euro spent—hampers advocacy for sustained funding.
Cultural factors, such as resistance to change or risk aversion, further slow adoption. Industries entrenched in traditional practices may distrust new technologies or fear operational disruptions during retrofits. In some cases, confidentiality concerns deter companies from sharing energy data or participating in collaborative platforms, fearing competitive disadvantages.
Finally, geographic and sectoral disparities might create uneven engagement. Programmes designed for dense industrial hubs may neglect rural SMEs, while sectors like heavy manufacturing (with high energy costs) may engage more actively than low-margin industries (e.g., food processing).

Cost effectiveness

The cost-effectiveness of such measures is highly variable, influenced by factors like the nature of activities, programme design, scope and budget allocations, all of which significantly shape outcomes.
While historical data from past initiatives suggest an average public subsidy range of approximately **0.005–0.015€ per kWh saved**[7] over the equipment's lifespan, these estimates carry inherent limitations.
Their reliability and transferability across contexts remain uncertain, as regional disparities, sector-specific dynamics and methodological inconsistencies in programme evaluation can skew results.

[7] https://unternehmen.oekobusiness.wien.at/en/

Voluntary Agreements

Voluntary Agreements (VAs) are contracts between the public administration and the industry in which the firm agrees to achieve a certain environmental objective and receives a subsidy to change its technology though R&D and innovation. The agreement is bilateral, between one firm and the administration, and requires a voluntary element on both sides[8].
VAs are increasingly recognized as effective tools to address systemic barriers to industrial energy efficiency. These barriers span informational gaps (e.g., limited awareness of savings potential), organizational challenges (e.g., competing internal priorities), technical capacity constraints and financial hesitancy. By mandating energy audits at the outset, VAs provide participants with actionable insights into company-specific savings opportunities while fostering knowledge-sharing networks that build technical competence and incentivize collective action.

Crucially, VAs help reframe efficiency as a strategic priority, mitigating inertia caused by short-term operational pressures or misaligned employee incentives. Their collaborative nature makes them particularly effective for small and medium-sized enterprises (SMEs), which often lack the resources to independently navigate complex efficiency upgrades. While subsidy programs may better address high upfront capital costs, VAs excel in environments where informational and capacity barriers dominate—a distinction that underscores their complementary role in holistic policy portfolios.

Success factors

The Wallonia region of Belgium hosts one of the EU's most successful industrial VA schemes, as highlighted in *EU-MORE D2.2*. This initiative has surpassed energy efficiency and CO_2 reduction targets by engaging 16 sectors, 173 enterprises and 203 production sites, collectively representing over 90% of the region's industrial energy consumption. Its success hinges on a win-win framework: industries (e.g., chemicals, steel, cement) commit to energy performance improvements, while the government offers financial incentives—such as tax deductions—and administrative flexibility.

Drawing on EU and global best practices (Cornelis, 2019), effective VAs require:

1. **Ambitious yet achievable targets**: Clear, sector-specific goals aligned with regional climate objectives.
2. **Balanced incentives and penalties**: Financial rewards (e.g., tax breaks) paired with non-compliance penalties to ensure accountability.
3. **Integration with policy mixes**: Synergies with regulations, subsidies, or carbon pricing to amplify impact.
4. **Robust governance**: Competent authorities, stringent monitoring/verification and third-party audits.
5. **Participant-centric design**: Tailored commitments for individual firms (not just sector-wide), energy management systems and platforms for knowledge-sharing.
6. **Cultural foundations**: Mutual trust between government and industry, alongside flexibility to adapt to evolving challenges.

VA adoption varies across Europe, with longstanding schemes concentrated in **Central, Northern and Western Europe** (e.g., Germany, Sweden), while Southern and Eastern EU states lag due to weaker trust and incentive frameworks (Cornelis, 2019). For instance, Malta and Cyprus lack industrial VAs entirely and

[8] https://www.eea.europa.eu/help/glossary/eea-glossary/voluntary-agreement#:~:text=A%20contract%20between%20the%20public,technology%20though%20R%26D%20and%20innovation.

Central/Eastern European uptake remains limited despite growing interest.
VAs thrive only as long as all parties derive mutual benefit. Regular revisions—updating targets, addressing emerging barriers and scaling proven practices—are critical to maintaining momentum. Wallonia's model exemplifies this adaptability, ensuring industries view efficiency not as a compliance burden but as a strategic advantage.

Barriers

Voluntary Agreements face systemic challenges that can undermine their effectiveness. At the governance level, a lack of mutual trust between governments and industries often stymies collaboration, compounded by poor coordination or even internal conflicts within governmental bodies. This is exacerbated by modest policy objectives, weak alignment with broader GHG reduction strategies and insufficient negotiation during scheme design, leaving targets ambiguous or unambitious. Structurally, the voluntary nature of these agreements reduces government leverage to incentivize participation, while inactive industry associations and companies' unwillingness to collaborate—driven by confidentiality concerns or competitive hesitancy—limit collective action.

Operational hurdles include absent timelines, unclear monitoring protocols and resource constraints (both administrative and corporate), which hinder implementation. Heavy reporting burdens and knowledge gaps in tools or methodologies further strain stakeholders, while uncertainties in cost-effectiveness calculations and target-setting create financial and operational risks. Critically, the lack of credible threats (e.g., alternative regulatory measures) diminishes urgency, allowing underperformance to go unchecked. Together, these barriers fragment accountability, dilute ambition and jeopardize the transformative potential of VAs.

Cost effectiveness

Quantitative data about the cost-effectiveness of programs based on voluntary agreements were not available from scientific or grey literature. Henriksson and Söderholm (2009) conducted an evaluation of the Swedish Program for Energy Efficiency (PFE), analysing its cost-effectiveness from a qualitative viewpoint. The cost-effectiveness of the PFE is analyzed through a combination of structural design features, participant behavior, and administrative challenges. The study highlights critical qualitative and systemic factors that influence the program's efficiency.

The PFE system primarily attracted energy-intensive companies, with 83% of participants having annual electricity costs exceeding SEK 1 million. This self-selection bias skews the program toward firms already incentivized to prioritize energy efficiency due to high operational costs. While these companies reported improved energy management practices and competence (e.g., through mandatory energy management systems), their participation raises questions about additionality. Many of these firms might have pursued investments even without PFE, given their inherent economic motivations. Conversely, low-energy-intensity firms—those with annual electricity costs below SEK 50,000—were significantly underrepresented, with only 1% choosing to join. This limits the program's broader impact, as smaller firms with less prior experience in energy efficiency could benefit more from structured guidance but remain outside the program's scope.

A key feature of PFE was its use of a uniform hurdle rate for evaluating energy efficiency investments. While this approach theoretically promotes cost-effective allocation of measures across participants, its success hinges on minimizing information asymmetries between firms and regulators. In practice, energy-intensive companies—often large and complex—faced internal principal-agent problems, where engineers may lack incentives to identify efficiency opportunities despite management priorities. At the same time, the program's administrative costs were higher than those of a simple electricity tax, involving dual oversight by the Swedish Energy Agency and the National Tax Board, as well as complex baseline assessments to verify

additionality. These administrative burdens reduce net benefits and show that trade-offs have to be made between policy precision and practicality.

Despite these challenges, PFE has demonstrably raised awareness and institutionalized energy management practices among participants. Interviews with firms indicate increased investment in efficiency measures and a shift away from outdated operational routines. Yet, the **program's overall cost-effectiveness remains constrained by its limited reach, administrative complexity and potential overlap with preexisting incentives.**

To enhance efficiency, the authors propose sector-specific agreements, hybrid policies combining taxes with targeted support for non-participants and reforms to incentivize participation among low-energy-intensity firms. Such adjustments could mitigate self-selection biases and better align the program's design with its objectives.

5. General Policy Recommendations

Based on the Policy review (D2.2) and desk research, we propose the following recommendations for improving policy measures regarding the acceleration of the replacement of old motors in the industrial sector. Important to emphasise is that on purpose, the recommendations are not prioritized, as advocated during some of the co-creation and national workshops by different actors. There are two important justifications for this: First, our work suggests an integrated approach combining several or all of these recommendations is to be preferred, to be most effective. Second, there is no "one-size fits all" approach. Each country has to build its integrated approach to motor replacement into its national policy frame. For example, in the German context it appeared as clear than energy saving obligations would not be part of the policy mix for motor replacement, given the national specificities, while they would make sense in countries such as France or Italy, which have a long tradition with this instrument.

- **Initiate a data collection program**

Use energy audits to collect baseline data on motor stock, including power rating, energy efficiency, age, and average load. This will lead to policy measures being designed and monitored more efficiently and could help companies optimise their investment decisions. Motor system assessments made by energy audits should be reported to the managing authority.

- **Initiate a subsidy scheme for motor system investments and a scrappage scheme targeting old motors**

Provide appropriate subsidies industrial companies for investing in motor systems identified by energy audits as having a high energy saving potential but where the investment is not sufficiently attractive from an economic point of view. Among other actions, update the list of eligible activities to include investments with high energy saving potential like the installation of VSDs. Set the subsidy rate carefully to deter free riders. The subsidies can also be connected to the scrappage of the old, inefficient motor, confirmed by certification.

- **Initiate a tax incentives scheme combined with Voluntary Agreements for "low- hanging fruits"**

Provide appropriate tax incentives combined with voluntary agreements for those investments identified by energy audits as having a high energy saving potential and that are economically attractive (i.e., payback <4 years and/or sufficiently high IRR) but which have not been implemented due to organisational barriers.

- **Update existing Energy Efficiency Obligation Schemes (EEOSs) to indirectly finance energy audits**

By updating the national EEOS (Energy Efficiency Obligation Scheme), Obligated Parties can be given the opportunity to meet their obligations through financing their clients' energy audits, resulting in a win-win situation. This will stimulate high quality energy audits and can also serve the collection of baseline data.

- **Provide free energy audits and capacity- building activities for SMEs**

SMEs are often unaware of the potential multiple benefits of motor investment and may not have the necessary resources to undertake high quality energy audits or implement energy management systems (EnMS). Free energy audits and capacity-building activities could help to fill this gap.

- **Initiate an information and capacity-building programmes**

Initiate information campaigns targeting every stakeholder involved in motor investment decisions in industry and the tertiary sector. Develop training programmes for energy auditors to keep them up to date with technological innovations and assure the quality of energy audits.

- **Attract private capital by aligning policies with the EU's Sustainable Finance Framework**

The EU Taxonomy Regulation, part of the EU's sustainable finance framework, could be updated to include replacing old motors as a dedicated green, or 'environmentally sustainable', economic activity. This can stimulate private capital companies to finance such investments.

The following are some general guidelines to keep in mind when developing any kind of motor replacement policy:

- **Follow an integrated approach**

Successful outcomes require integrated sets of measures that reinforce each other, including baseline data collection, information campaigns and capacity building, encouraging the implementation of measures identified by energy audits, subsidies or tax relief where appropriate, and a system for impact reporting.

- **Follow a stick-and-carrot approach**

Incentives should be combined with penalties for non-compliance. Financial incentives should be carefully designed to ensure that participation is worth the effort and that free-riders are deterred.

- **Plan long-term**

A programme should run long enough for market participants to become familiar with it, but financial incentives should not apply for so long that they distort market price mechanisms.

- **Keep it clear, simple and transparent**

Subsidies should be clearly specified, including variations based on product specifications (e.g. motor size) or usage. Selection procedures should be transparent, to stimulate participation and build mutual trust.

- **Build upon available best practices and past programs**

There is no need to re-invent the wheel. Learn from the success or failure of past or existing programmes and best practices, and adapt them to the specifics of your country, region, or sector.

- **Integrate and use calculation tools following a life-cycle approach**

Proper calculation tools, including the one developed by EU-MORE, combined with information and training campaigns, can stimulate the adoption of a life-cycle approach, which can be a strong driver for the early replacement of inefficient motors.

- **Follow a motor system approach**

The benefits of replacing an old motor can be enhanced by addressing the entire motor system rather than the individual motor alone. Such an approach can lead to a re-engineering project to allow for proper dimensioning of the motor and the associated process equipment.

- **Take non-energy benefits into account for programme design and evaluation**

Raising awareness about the non-energy benefits can help to make motor replacement investments more attractive to industrial decision makers.

- **Consider material circularity and, availability**

Programmes for accelerated motor replacement should be aware of the life-cycle material balance, including the material savings in power generation triggered by energy savings. They

should go together with measures stimulating recyclability and minimising the use of critical raw materials.

- **Keep up with technological innovations (Digitisation, AI, etc)**

Smart, innovative technology (digitalisation, artificial intelligence, etc.) can be coupled with robust and mature products to optimise energy efficiencies and monitor the resulting energy savings.

6. Specific National Policy Recommendations

In this section, the country-specific policy recommendations developed through a co-creation process with stakeholders are presented.

For each EU-MORE partner country, a section highlighting the specific status of the policy framework for motors, barriers and key drivers for the implementation of new programmes are presented. Following, a set of initial recommendations, along with the feedback provided by national stakeholders during the National and Co-Creation workshops, are reported in order to show in detail the policy co-creation process.

The final recommendations, derived from the integration of the received feedback into the initial recommendations, are eventually proposed.

6.1 Austria

Status, specific barriers, key drivers

Austria has developed a multifaceted policy framework to advance energy efficiency and electric motor replacement, anchored in both federal and regional initiatives. Central to this framework is the *Umweltförderung im Inland (UFI)*, a federal subsidy program operational since 1993. UFI supports investments in environmental and climate protection, including motor-driven systems, under broader categories such as "Energy-saving Measures in Enterprises." While a dedicated "Energy-efficient drives" program (2011–2012) provided direct subsidies for motor replacements, it was discontinued due to low uptake, though motor-related upgrades remain eligible under UFI's general funding streams.

Complementing UFI, regional programs like *OekoBusiness Wien* offer co-financed environmental consultancy for Vienna-based companies, identifying motor-related savings in systems such as compressed air or pumps. At the regulatory level, Austria mandates *energy audits for large companies* every four years under the Energy Efficiency Act (EEffG), requiring analysis of motor-driven systems (e.g., pumps, fans) and actionable recommendations. For SMEs, subsidies are available to adopt *energy management systems*, which include monitoring equipment and training that indirectly promote motor efficiency.

The *klimaaktiv Energy Efficient Enterprises* program, part of the climate protection initiative "klimaaktiv" of the Austrian Federal Ministry for Climate Action, further strengthens this ecosystem by providing sector-specific audit guides, tools, and training for motor-driven systems. This initiative, managed by the Austrian Energy Agency, collaborates with industry partners to disseminate best practices and technical guidelines, such as using variable speed drives or high-efficiency motors.

Initial policy recommendations and input from stakeholders

Initial Recommendation #1: Stipulation of mandatory energy saving targets for companies and/or energy utilities within the Austrian Energy Efficiency Act

Feedback received

The implementation of such targets is a decision made at the highest political level. While the current version of the Energy Efficiency Act does not include this provision, it has been part of the legislation in the past. Moving forward, there will be a requirement (art. 11 EED) for companies to publish their action plans derived from the energy audits. This obligation is expected to create indirect pressure on organizations to implement the energy efficiency measures identified in these audits, thereby contributing to the achievement of national energy-saving targets.

Initial Recommendation #2: Inclusion of measure description for motor replacement and/or VSD installation in the Austrian Energy Efficiency Measures Ordinance, clarification of saving calculation and life-time assumptions

Feedback received

This measure is primarily relevant for industrial end-users, particularly in scenarios where energy-saving targets (e.g. obligation schemes for energy utilities, as previously implemented in Austria) are established within energy efficiency legislation. In the absence of such targets, industrial end-users are not required to consider this measure.

Initial Recommendation #3: Mandatory implementation of energy audit recommendations (energy efficiency measures defined in the Action Plan) for measures with high Internal Rate of Return (or below defined Payback Time, e.g. 1 or 2 years). An alternative approach could require the implementation of short-term measures with low payback periods as a prerequisite for accessing investment funding for long-term measures.

Feedback received

The Austrian Energy Efficiency Act does not currently mandate such requirements, partly due to concerns over property rights encroachment. However, it does obligate organizations to justify why specific measures are not implemented. Additionally, future regulations will require the publication of the action plans, signed by CEOs, resulting from the energy audits, which is expected to create indirect pressure for the implementation of the recommended energy efficiency measures.

Initial Recommendation #4: Inclusion of motor inventory lists and nameplate data in energy audit requirements

Feedback received

Energy audit requirements are intentionally formulated in broad terms to ensure applicability across a wide range of scenarios. This approach provides companies with greater flexibility and autonomy in meeting audit standards. However, the existing legal framework already allows for the analysis of electric motors that significantly influence energy consumption or serve as primary energy-consuming components.

While the inclusion of motor inventory lists and nameplate data could enhance the precision of energy audits, it may also lead to increased costs for businesses. Such additional obligations are often perceived negatively due to the potential financial and administrative burden they impose.

Initial Recommendation #5: Mandatory monitoring of the main energy consumers

Feedback received

This is seen as additional burden for the companies: After all, the obligated companies are so different in their consumption profile that this is not really helpful, but probably simply raises more questions than answers. But it would be possible to include it as an precondition for investment subsidies for energy efficiency measures to measure the system, above a certain power threshold (e.g. 30 kW). On the other hand, this would increase the burden for companies to gain subsidies.

Initial Recommendation #6: Explicit mentioning of motor replacement and installation of VSD under Austrian subsidy scheme for energy efficiency in industry

Feedback received

Currently, the replacement of electric motors or installation of VSD is not explicitly mentioned under the Austrian subsidy scheme for energy efficiency in industry. The text for these kinds of measures is very general: "Efficiency increases in industrial processes and systems with a significant technological and ecological difference to existing systems". This topic is to be discussed with relevant stakeholders. (BMK, KPC)

Initial Recommendation #7: Stepwise inclusion of specifications for motor inventory list and/or purchase requirements of IE4 (or high efficient) motors in plan of measures to be implemented by klimaaktiv partner companies

Feedback received

The Austrian Energy Agency presented the EU-MORE project and the idea to include the motor inventory list in the recommendations for the plan of measures to be implemented by klimaaktiv partner companies in October 2024 at the project partner jour fix and received positive feedback. Further details will be decided in 2025.

Initial Recommendation #8: Raising Awareness for potential of motor optimization within the Klimaaktiv programme

Feedback received

The training materials for pumps, fans and cooling currently include data on motor efficiency. However, it may be useful to intensify these activities and probably establish a separate focus area for electric motors and variable speed drives.

Final recommendations

Initial Recommendation #1: Stipulation of mandatory energy saving targets for companies and/or energy utilities within the Austrian Energy Efficiency Act

While the current version of the Energy Efficiency Act does not include this provision, it has been part of the legislation in the past.

Initial Recommendation #2: Inclusion of measure description for motor replacement and/or VSD installation in the Austrian Energy Efficiency Measures Ordinance, clarification of saving calculation and life-time assumptions

This measure is primarily relevant for industrial end-users, particularly in scenarios where energy-saving targets are established within energy efficiency legislation, which is currently not the case.

Initial Recommendation #3: Mandatory implementation of energy audit recommendations (energy efficiency measures defined in the Action Plan) for measures with high Internal Rate of Return

Initial Recommendation #4: Monitoring of the main energy consumers (e.g. 50 kW) as a precondition for investment subsidies for energy efficiency measures

Initial Recommendation #5: Explicit mentioning of motor replacement and installation of VSD under Austrian subsidy scheme for energy efficiency in industry

Currently, the replacement of electric motors or installation of VSD is not explicitly mentioned under the Austrian subsidy scheme for energy efficiency in industry, but it can and is subsidised.

Initial Recommendation #6: Stepwise inclusion of specifications for motor inventory list and/or purchase requirements of IE4 (or high efficient) motors in plan of measures to be implemented by klimaaktiv partner companies

These measures are going to be recommended to partner companies, which do not have such an inventory or purchase requirements, or do not have these measures included in their action plans. Some companies already started this process.

Initial Recommendation #7: Raising Awareness for potential of motor optimization within the klimaaktiv programme

Though motor replacement is already included in several technological specific information (e.g. pumps and fans), an additional motor specific focus area is recommended.

6.2 Germany

Status, specific barriers, key drivers

Germany has established a strong policy framework to promote energy efficiency, with a particular focus on replacing outdated electric motors. Various federal ministries and agencies, including the Federal Ministry for Economic Affairs and Climate Action (BMWK), the Federal Ministry for the Environment (BMUV), and the Federal Office for Economic Affairs and Export Control (BAFA), play crucial roles in implementing policies and funding programs aimed at increasing efficiency in industrial sectors.

Several funding programs complement these regulations by providing financial support to companies looking to upgrade their equipment. The KfW Energy Efficiency Programme offers low-interest loans to businesses investing in more energy-efficient production processes, while the Federal Funding for Energy and Resource Efficiency in the Economy (EEW) provides grants for replacing inefficient motors and implementing advanced cross-sectional technologies. Previously, the STEP up! Programme also encouraged efficiency improvements in industrial applications.

Despite these efforts, several barriers slow the adoption of energy-efficient electric motors. One of the biggest challenges is the high initial investment cost, which makes many businesses hesitant to replace functioning but inefficient equipment. The bureaucratic complexity of applying for funding further discourages smaller companies, as does the competitive nature of some funding programs, which favor larger enterprises. Additionally, many companies lack awareness of available incentives or the technical knowledge to assess potential energy savings. Integration challenges also pose an issue, as upgrading to new motor systems often requires costly modifications to existing industrial processes.

Financial incentives remain one of the strongest motivators, with grants covering up to 40% of investment costs for small and medium-sized enterprises. The rise of the energy costs make efficiency improvements more attractive, as businesses seek to reduce operational expenses.

Germany's approach to accelerating the replacement of electric motors is comprehensive, balancing regulatory mandates with financial support and technological innovation. However, to fully realize its energy and climate goals, the country will need to address remaining barriers by simplifying funding access, increasing awareness, and ensuring that efficiency improvements are economically viable for businesses of all sizes.

Initial recommendations and input from stakeholders

Initial Recommendation #1: Introduce Innovation Programs, Grants and Subsidies to support old motor replacement

Feedback received

Within the framework of the existing programmes and modules under the Federal Funding for Energy and Resource Efficiency in the Economy (EEW), there are already opportunities and approaches in place. Many logical and effective measures are already supported under the EEW, applicable to both individual motors and motor systems. However, despite these provisions, awareness and market acceptance remain limited. There is a clear need for more widespread information dissemination to bridge this gap. Electric motors are

already eligible for subsidies under Module 1 of the EEW. However, this support is not extended to large companies, creating a gap in the programme's reach.

From a business point of view, the focus is on achieving profitability while contributing to climate protection. For measures to gain traction, they must either yield quick returns or be supported by regulatory frameworks.

Companies and plant operators typically think in terms of processes rather than individual components. This raises a critical question: How can motors be decoupled from the broader system to make single-motor upgrades more appealing to businesses? Solutions involving Variable Speed Drives (VSDs) or frequency converters are less straightforward, as they require consideration of the entire system rather than just individual components. Shutting down plants or processes for upgrades is often impractical for companies, even if the long-term efficiency gains are significant. This highlights a key barrier to implementation.

A common sentiment among companies is, "I won't proceed without a subsidy." This underscores the importance of financial incentives in driving the adoption of energy-efficient measures.

Initial Recommendation #2: Consider introducing Tax rebates with voluntary commitments

Feedback received

Tax-based solutions carry a relatively high risk of free-rider effects, where companies benefit without contributing meaningfully to energy efficiency goals. Additionally, challenges arise with company legal structures that do not pay taxes and therefore cannot directly receive subsidies. A combination of voluntary commitments and tax incentives could be an effective approach for smaller motors with shorter lifespans. This approach balances flexibility with financial motivation.

To support implementation, easy-to-use templates for reporting would be essential. These templates would streamline compliance and ensure clarity in documenting energy efficiency measures.

Incorporating existing obligations—such as those under the Energy Efficiency Directive (EED), including energy audits and Energy Management Systems (EnMS)—into industry implementation plans shows promise. This approach would involve energy auditors and managers more actively in the process.

Initial Recommendation #3: Develop and introduce an information campaign and/or capacity building program

Feedback received

Energy agencies should play a proactive role in providing tailored support to industrial companies, helping them navigate the complexities of motor system optimization and energy efficiency measures. Energy agencies should develop a portfolio of materials, including flyers, guides and a dedicated website featuring best practices, case studies and practical tools for companies.

Establishing one-stop shops for small and medium-sized enterprises (SMEs) would offer comprehensive support, going beyond free audits to include implementation assistance and consulting services. Information campaigns should highlight the best practice examples to demonstrate the tangible benefits of motor system optimization and inspire broader adoption.

Energy consultants should be trained through a "train-the-trainer" approach, as the topic of motors (with the exception of ventilation systems) is often overlooked in current energy efficiency discussions.

The funding landscape is already robust, but information programmes must be strategically combined with existing funding initiatives to maximize their impact and ensure seamless implementation.

Final recommendations

Final Recommendation #1: Building on the existing EEW[9], focus the existing program more on the replacement of older electric motors with sufficiently long runtimes for a defined time period (e.g. during 2-3 years). Focus on private companies, municipal facilities (EED: requirements for public buildings!), consultants and service providers.

Final Recommendation #2: Introduce an implementation obligation for investments with high returns: companies should be required to implement investments in electric motors that demonstrate a high rate of return and have sufficiently long runtimes.

Final Recommendation #3: Subsidies and Tax Incentives for motors with shorter runtime: a combination of subsidies and voluntary commitments coupled with tax incentives could be introduced to encourage adoption. Additional incentives could be provided by network operators as part of voluntary commitments or through adjustments to network charges. This approach should align with the Energy Efficiency First principle of the EED, ensuring that energy efficiency is prioritized in decision-making.

Final Recommendation #4: Couple the EEW programme with a broad information campaign and/or One-Stop-Shops to raise awareness and provide accessible resources for companies, especially examples of best practices to inspire and drive the implementation.

Final Recommendation #5: Introduce free energy audits to support the companies in the identification of opportunities for motor replacement and system optimization.

6.3 Greece

Status, specific barriers, key drivers

The Greek National Energy and Climate Plan (NECP) sets ambitious targets for 2030, including a 42% reduction in greenhouse gas emissions, a 35% share of renewables in gross final energy consumption, and a decrease in total energy use compared to 2017.

A key aspect of Greece's strategy is the implementation of energy efficiency obligation schemes, which require large industrial consumers to either conduct energy audits or adopt energy management systems. These obligations are aligned with the EU Energy Efficiency Directive and encourage industries to adopt more efficient technologies, including advanced electric motors. Moreover, several financing mechanisms are in place to support businesses in improving their energy efficiency. The "Antonis Tritsis" Programme, for example, provides funding for upgrading municipal water and wastewater infrastructure, replacing old pumps and motors, and integrating renewable energy solutions. Similarly, the Green Transition SMEs Programme helps small and medium-sized enterprises invest in energy-efficient technologies and modernize their production processes

[9] Under the assumption that the programme will remain active in the future.

Discussions during the EU-MORE Co-Creation Workshop in Greece highlighted several challenges that hinder the large-scale replacement of inefficient electric motors. A major issue is the lack of accurate energy consumption data within many companies, making it difficult to assess which investments would yield the best cost-benefit ratio. Compounding this problem is a shortage of qualified energy auditors and, in some cases, the poor quality of energy audits, which limits their effectiveness.

Additionally, many companies, particularly Municipal Water and Sewerage Companies, struggle to secure funding for energy efficiency projects. These organizations often lack access to financial loans and must rely on government-funded programs, which have limited budgets and cannot fully meet demand.

The workshop also highlighted the Energy Efficiency Obligation Scheme as an underutilized tool. Energy suppliers, as obligated entities, could potentially finance feasibility studies for energy-saving projects in municipal water and wastewater companies, ensuring more efficient use of funds.

Initial recommendations and input from stakeholders

Based on the aforementioned analysis in sections 4,5 & 6.4.1 of this deliverable, we propose the following initial recommendations, to further promote energy efficiency in the Greek industrial and tertiary sector through the replacement of old and inefficient electric motors.

Initial Recommendation #1: Voluntary Agreement for the replacement of old and inefficient electric motors – mandatory replacements following energy audits recommendations with a high enough IRR (or low payback time),

following the relevant good practices in the Region of Flanders (Belgium), the PFE program in Sweden and the Energy-Investment Allowance (the Netherlands)

Feedback received

Stakeholders during the co-creation workshop, argued there have been attempts in the past to implement Voluntary Agreements in Greece, however no such programs were implemented, probably due to a combination of factors including the lack of the appropriate culture and mutual trust between all interested parties. On the contrary, such programs have proved to be very successful in countries (e.g. Belgium, the Netherlands etc) where the appropriate culture has been established long time ago.

Initial Recommendation #2: Scrappage / withdrawal scheme (subsidy/grant/tax rebate) for the replacement of old and inefficient electric, in cases with low IRR but high energy saving potential,

following the relevant good practices of the PPEC program (Portugal) and the Prokilowatt program (Switzerland)

Feedback received

SMEs face significant problems in finding financing for energy-saving investment projects. Since there is a related inability to obtain loans from financial institutions, they are forced to turn to available funding programs.

Initially, various financial tools should focus on preparing the necessary studies, energy audits, assessing the production equipment to identify the optimal investments with the best cost/benefit ratio.

The available budgets for related funding programs are particularly small and insufficient to meet the increased needs of businesses, especially SMEs.

Initial Recommendation #3: Initiate a program for gathering baseline data on motors age, stock, power etc to enable more efficient design and monitoring of policy measures – this could be set as a prerequisite for companies to participate and benefit from subsidy schemes

Feedback received

During the design of relevant funding programs, a key issue is the lack of related data on energy consumption, equipment power, and the age of eligible businesses. There is also difficulty in finding a sufficient number of qualified energy auditors to carry out the necessary energy audits and identify investments with the optimal cost/benefit ratio.

Initial Recommendation #4: Initiate a program similar to Klimaaktiv and OekoBusiness Vienna, to increase awareness, to provide trainings, to monitor interventions and savings and to provide (subsidise) free initial energy audits for SMEs,

Feedback received

Increased awareness combined with high quality energy audits and adequate data collection could greatly assist companies to make more informed decisions on such energy saving investments.

Initial Recommendation #5: Update the national EEOS (Energy Efficiency Obligation Scheme) by including the replacement of e-motors as an eligible activity and by adding a dedicated BU equation

Feedback received

Businesses could indirectly benefit from the framework governing the Energy Efficiency Obligation Scheme. More specifically, the obligated parties under this framework (mainly energy providers) could fulfil their obligations by funding the necessary studies for energy-saving actions on behalf of their clients (typically SMEs and in particular companies with high energy saving potential like water and wastewater treatment companies).

Final recommendations

Final Recommendation #1: Subsidy scheme for investments with a payback of more than 3 years

Subsidy schemes should provide sufficient funding in cases where payback is expected in more than 3 years but there is a significant energy saving potential. Subsidy rated should be carefully selected to deter free-riders.

Apart from securing the necessary funding, the design of such schemes should follow a participatory approach, engaging all interested stakeholders (policy makers, managing authorities of such programs, market representatives etc)

Final Recommendation #2: Program on data collection

Initiate a program focusing on the collection of necessary data, enabling in this way a better design of subsidy schemes and facilitating also financial investment decisions in participating companies.

Final Recommendation #3: Program on increasing awareness and provision of trainings

The government should initiate a program on increasing awareness of all relevant stakeholders, including policy makers, managing authorities' representatives, production/maintenance plant managers. Moreover, there should be regular trainings to ensure high quality energy audits and that energy auditors keep up with the latest technological advancements.

Final Recommendation #4: Take advantage of the current EEOS

Take advantage of the established energy efficiency obligation scheme to further enable the obligated entities (energy suppliers) in Greece to partially meet their obligations by directly funding their clients' necessary studies or energy audits related to motor systems improvement. In this win-win situation, obligated parties could offer free energy audits to their SME clients.

6.4 Portugal

Status, specific barriers, key drivers

Portugal's efforts to enforce energy efficiency regulations for electric motors and motor systems face systemic challenges. Non-compliant IE1 and IE2 motors continue to circulate despite the EU ban, facilitated by legal loopholes such as mislabeling non-continuous duty motors for continuous applications. Market surveillance agencies indeed lack the technical capacity and resources to effectively monitor compliance, particularly in B2B transactions where enforcement is virtually absent.

Regulatory frameworks remain focused on individual motors rather than the entire motor system (gearboxes, pumps, fans), missing opportunities to optimize overall efficiency.

Energy audits for energy-intensive industries under the SGCIE framework occur only every eight years, a timeframe stakeholders criticize as insufficient to drive meaningful improvements. A lack of training and awareness among stakeholders—particularly designers, assemblers and SMEs—exacerbates distrust and slows progress. Corporate decision-making is further fragmented, as energy efficiency competes with operational priorities like production uptime and short-term financial returns.

Opportunities for progress lie in strengthening enforcement through enhanced technical training for surveillance bodies like ASAE, coupled with stricter penalties for non-compliance. Expanding regulations to cover entire motor systems rather than individual components could unlock significant efficiency gains. Financial incentives, such as subsidies for projects with longer payback periods or the introduction of white certificates to monetize energy savings, would address economic barriers. Capacity-building initiatives, including technical training programs led by manufacturers' associations like AGEFE and independent audits to validate efficiency claims, could rebuild trust and awareness. Policy reforms, such as shortening SGCIE audit cycles and integrating ISO 50001 energy management systems, would accelerate adoption.

Collaborative governance, involving partnerships between regulators, manufacturers and end-users, could align priorities and streamline decision-making. Finally, refocusing energy audits on process optimization and critical equipment would highlight tangible benefits, driving informed investments in efficiency.

Initial recommendations and input from stakeholders

Initial Recommendation #1: Capacity Building Programmes for SMEs and Large Consumers

To increase awareness and build technical expertise, capacity-building programmes should be established, targeting SMEs and other major energy consumers. These programmes could include:

- Awareness Campaigns:
  Educate stakeholders on the benefits of replacing inefficient motors and optimizing motor systems, while providing information on available support mechanisms. Campaigns should target both technical staff and decision-makers within companies.
- Training Seminars and Workshops:
  Equip technical staff with the skills and knowledge needed to implement energy efficiency measures effectively.
- Support Framework for SMEs:
  Accelerate the adoption of energy audits by offering them at no cost or a reduced cost. These audits would help SMEs identify energy-saving opportunities, such as motor replacement.

Feedback received

The lack of training and awareness-raising activities across the value chain was emphasized, particularly for equipment designers and companies assembling machines and motor systems. These stakeholders play a critical role in influencing end-users' decisions. It was also suggested that energy efficiency campaigns should be relaunched broadly, with a focus on technical training and awareness of energy and non-energy benefits (e.g., economic, environmental and social). Manufacturers and their association (AGEFE) expressed the willingness to support technical training programmes covering the entire motor system to drive market transformation.

Initial Recommendation #2: Setting more ambitious mandatory Energy Savings Targets

The current mandatory target for companies consuming less than 1,000 toe/year is a 4% reduction in energy consumption over eight years. However, most SMEs in Portugal fall under this category. To accelerate energy savings, the targets or the timeframe for achieving them could be revised. Additionally, financial or tax incentives could be introduced to help SMEs meet these more ambitious goals.

Feedback received

The consulted stakeholders highlighted the need for shorter audit intervals under the SGCIE (currently every 8 years) and support for measures with paybacks exceeding 3 years (e.g., subsidized interest, subsidies). It was also suggested that more ambitious targets should be set for SMEs voluntarily adhering to energy audits, supported by programmes like PPEC (Plan to Promote Efficiency in Consumption) or the Environmental Fund. The importance of monitoring systems to promote energy management systems (ISO 50001) was also emphasized.

Initial Recommendation #3: Creation of an energy audit methodology and identification of measures to improve energy efficiency in motive power systems within the scope of the SGCIE (Management System for Intensive Energy Consumers).

Feedback received

Energy audits should focus on improving production processes and critical equipment (e.g., those with over 2,000 hours of annual operation). Audits should raise awareness of the gains achievable through process monitoring and highlight the benefits of optimizing the entire motor system, including gearboxes, pumps and fans.

The creation of an independent external body to conduct energy studies or develop typical case studies could increase end-user trust in the data presented.

Initial Recommendation #4: Mandatory inclusion of all relevant data on electric motors and motor systems, including equipment nameplates, in the energy audit reports.

Energy audit requirements should mandate the inclusion of all relevant data on motor systems, such as equipment nameplates, to ensure comprehensive assessments and identify optimization opportunities.

Feedback received

Including detailed motor system data (e.g., equipment nameplates) in energy audits is crucial for identifying optimization opportunities. However, market surveillance needs to be strengthened to ensure compliance with regulations, as non-compliant equipment (e.g., IE1 and IE2 motors) is still being sold through legal loopholes.

Initial Recommendation #5: Mandatory Monitoring of High-Energy-Consuming Equipment

Companies should be required to monitor a specified number of high-energy-consuming units (e.g., the top five electric motors) within their facilities. This would help identify long-term opportunities for significant energy savings.

Feedback received

There is a lack of reliable information to support case for energy efficient measures in motor systems. Monitoring the energy use of electric motors, at least the major consumers, could help support these decisions and, additionally, help in identifying opportunities for continuous improvement.

Initial Recommendation #6: Creation of a support mechanism (e.g. tax benefits, low-interest loans, subsidies, etc.) for companies that exceed their energy reduction objectives/targets as well as their emissions reduction objectives/targets to reward them for their good performance.

A support mechanism (e.g., tax benefits, low-interest loans, or subsidies) should be established to reward companies that surpass their energy and emissions reduction targets. This would encourage greater ambition and compliance with energy efficiency policies.

Feedback received

The creation of a White Certificates scheme (energy-saving certificates) could incentivize the replacement of electric motors and motor systems. These certificates could be traded on a market, rewarding companies for energy savings and aligning public and private efforts toward sustainability goals. Financial incentives (e.g., tax benefits, low-interest loans, subsidies) are crucial to overcome the initial cost barrier of more efficient solutions, which remains a significant obstacle for end-users.

Final recommendations

Final Recommendation #1: Empowerment of market surveillance authority

Reinforcement of market surveillance authorities staff and provision of adequate technical training in order to assure the effective enforcement of the existing EU regulations.

Final Recommendation #2: Zero-Tolerance framework for non-compliant equipment and/stakeholders

Creation of a zero-tolerance framework to assure market compliance of all available equipment (electric motors and motor systems) in the market. This framework should include heavy penalties for non-compliant equipment and/stakeholders and will support the activities of the market surveillance authorities.

Final Recommendation #3: Regulation for motors systems

Creation of regulation similar to motors that encompasses all the components in the motors system (e.g., pumps, fans, gearboxes etc.), due to their high impact on the overall efficiency of a motor system, which can exceed by several times the improvement in efficiency associated with replacing only the motor.

Final Recommendation #4: Support scheme for measures with payback above 3 years

Creation of support schemes for energy efficiency measures (identified in the energy audit) with high savings potential and payback above three years. These measures usually tend not to be implemented due to its high payback period. A support scheme using subsidised interest, subsidies, or other form of support should be considered due to the high savings impact that these measures tend to have.

Final Recommendation #5: Technical training and awareness raising activities across the value chain

There is a widespread lack of energy efficiency training for all the stakeholders across the value chain, which includes regulator, market surveillance authority, designers and companies that assemble machines or motor systems and end-users (e.g. company staff in production and maintenance areas, as well as administration, finance and purchasing areas). It is essential that this training encompasses all these areas/people (with different skills sets and different visions on the priority of energy efficiency) by providing different technical approaches (depending on the work area) to the multiple benefits of replacing old inefficient motors and motor systems.

Final Recommendation #6: Energy Audits 2.0 – Improvement of savings and energy audits

For example, in Portugal companies covered by the SGCIE- Energy-intensive management system are required to carry out energy audits every 8 years. Energy Audits 2.0 can tighten this requirement, as well as the savings targets (4 per cent over eight years) in order to achieve higher efficiency levels in industry. Combining this recommendation with the above mentioned "Support scheme for measures with payback above 3 years" will have a significant impact in terms of energy savings in industry. The energy audits

guidelines should also be revised (if available) and give more focus to optimizing the industrial process, critical equipment namely motors systems (with more than 2,000 hours of annual operation) and on raising awareness on the potential gains that can be made through monitoring.

Final Recommendation #7: White Motor Certificate Scheme

Creation of white certificates for electric motors and motors systems, were companies that go beyond their performance targets (due to motor and/or motor systems replacement) are rewarded and can trade these certificates in the market.

6.5 The Netherlands

Status, specific barriers, key drivers

The Netherlands has established a comprehensive policy framework to achieve its climate targets, including a 55% net greenhouse gas (GHG) reduction by 2030 and climate neutrality by 2050, aligned with the EU Climate Law.

Electric motor efficiency is addressed through mandatory energy audits for large companies (since July 2023), requiring analysis of motor systems exceeding 15 kW. Financial incentives, including tax deductions (EIA) for IE3/IE4/IE5 motors, subsidies (VEKI) for industrial decarbonization and tax benefits (MIA/VAMIL), complement regulatory measures. The Energy List, updated annually, specifies eligibility criteria for high-efficiency motors, accelerating market adoption.

Financial constraints, such as high upfront costs and long payback periods for advanced motor systems, hinder investments despite subsidies like VEKI targeting projects with delayed returns.

Initial recommendations and input from stakeholders

Initial Recommendation #1: Introduce a Capacity Building Program and offer free or subsidized energy audits

Launch a program to increase awareness and provide training (e.g., using the IEA EMSA tool) on energy-efficient motor replacements. Include awareness campaigns to educate stakeholders on benefits and available subsidies. Offer subsidized or free energy audits for SMEs to identify energy-saving opportunities, including motor replacement. Draw inspiration from successful capacity building programs in Austria (Klimaaktiv, OekoBusiness Vienna) or Switzerland (Topmotors).

Feedback received

There is currently no capacity-building or training program for the energy audits in the Netherlands, as no need for such a program has been identified. Energy advisors conducting audits are not required to hold formal qualifications, yet the quality of audits has generally been adequate. Approximately 50% of companies have responded and provided audits based on a guiding template from RVO.

While audits can be subsidized, most companies only require minor audits. Large companies are already obligated to conduct audits, making subsidies unnecessary in their case. However, there may be a need for knowledge-sharing. Under EIA audits can be subsidized, but only up to 10%.

Ensuring audit quality is crucial and improvements should serve as a foundation for further action. The focus should be on overall system efficiency, not just motors. This policy alone would not resolve the issue, as companies are generally aware of these inefficiencies but lack the incentive to invest. A more structured approach is needed, allowing companies to demonstrate compliance step by step (e.g., completing an audit and then moving on to the next stage). Additionally, efforts should be made to minimize replacement costs as much as possible.

Initial Recommendation #2: Consider an alternative financial metric for the current Energy Saving Obligation

Consider alternative financial KPIs (e.g., Internal Rate of Return - IRR) to evaluate mandatory energy-saving measures, ensuring projects with longer-term benefits are not overlooked. Alternatively, revise the current payback time (PBT) threshold (currently <5 years) based on ongoing monitoring and evaluation of the program's impact.

Feedback received

The 5-year payback time (PBT) criterion is under evaluation by the Ministry and may be adjusted in the future. However, no consideration has yet been given to revising the criteria to incorporate other indicators, such as the internal rate of return (IRR). Companies with an energy audit obligation are required to identify and report cost-efficient energy efficiency measures, even if the measures have longer PBTs.

The payback period could be extended beyond five years—preferably to seven or ten. However, from an economic perspective, this approach raises concerns, as it mandates companies to allocate capital in ways that may not align with their best investment opportunities. For example, forcing companies to replace drives when other investments might yield greater returns could be counterproductive.

Initial Recommendation #3: Develop a Database with Motor Systems information

Develop a harmonized database of motors containing information on age, operating hours, rated power and device/system powered, derived from the mandatory investigation on motor driven systems. Use the database to improve monitoring, benchmarking and targeted policy interventions for motor replacements.

Feedback received

The Ministry is currently deliberating whether to establish an inventory of electric drive systems using data collected from mandatory audits on motors above 15 kW (Energy Saving Investigation Obligation). Discussions with RVO are ongoing and input from EU-MORE could be valuable in highlighting the benefits of replacing electric motors. The 15-kW threshold for the Investigation Obligation is likely to remain unchanged, as most motors above this threshold already operate continuously or for long periods, resulting in high operating hours. Companies have not perceived the motor investigation obligation as a significant administrative burden.

The need for an inventory at company-level, rather than at national level, has been underlined to foster the collection of motor data and assess the motors currently in operation in industry. This would also promote the company' awareness about the usage of motors and their energy consumption.

Grid congestion in the Netherlands increases pressure on companies to optimize their energy use. In the Netherlands, many companies maintain a stock of motors, replacing broken ones with spare units from their inventory—regardless of efficiency or modernity. When a motor fails, it is repaired and returned to stock,

creating a continuous cycle where outdated motors remain in use simply because repairing them is cheaper than replacing them.

Instead of allowing this practice to persist, these motors should be recycled rather than being shipped to other countries, as sometimes happens. Companies should be required to discontinue the stockpiling of outdated motors—potentially by enforcing a rule that prohibits the repair of motors older than a certain number of years.

Maintenance companies, which service multiple industries in a given area, also contribute to this cycle by providing outdated motors to businesses. Recycling subsidies could encourage companies to dispose of inefficient motors. However, replacing stock motors is not economically attractive for businesses, as maintenance budgets—typically quite limited—are separate from other corporate budgets.

Efforts to train service and maintenance companies on more efficient motor technologies have been attempted but failed due to a lack of participation. These businesses are often small and primarily respond to customer demand. For real change, there must be industry-driven demand for efficient motors.

Initial Recommendation #4 – Integrate the identification of Non-Energy Benefits in the Motor Systems Analysis to enhance the attractiveness and overall value proposition of motor replacement initiatives

Include the identification of Non-Energy Benefits (NEBs) in the mandatory motor analysis template, in compliance with Article 11 of the Energy Efficiency Directive (EED). Update the analysis template to highlight NEBs such as increased reliability, reduced maintenance, improved process control and extended equipment lifespan for various motor-driven systems (motors, pumps, fans, compressors).

A suggested modification of the template[10] to include NEBs is proposed in the following:

Table 2: Suggested integration of NEBs into the Mandatory Analysis of Motor System template

Electric Drive System	Relevant Characteristics for Periodic Inspection	Possible Measures	Possible Non-Energy Benefits
Motor Machine	I) Older than 15 years or having low efficiency (<IE3) (efficiency according to EU Regulation 2019/1781).	Replacement of motor and/or application at the end of its economic life with high-efficiency models with proper sizing.	- Increased reliability due to new technology. - Lower maintenance from modern motors with less wear. - Improved process control, leading to better product quality.
Pump (including motor)	II) Older than 15 years or having low efficiency (lower than the minimum efficiency according to EU Regulation 547/2012).	Replacement of pump and motor with energy-efficient models.	- Extended equipment lifespan. - Reduced maintenance costs due to new pumps. - Better operational stability.
Fan (including motor)	III) Older than 10 years or having low efficiency (lower than the minimum efficiency according to EU Regulation 327/2011).	Replacement of fan and motor with efficient models and capacity adjustment.	- Improved air quality through better ventilation control. - Lower noise emissions, improving the working

[10] Template available (in Dutch) at: https://www.rvo.nl/sites/default/files/2023-10/sjabloon-analyse-aandrijfsystemen-onderzoeksplicht-definitief-oktober-2023.docx

			environment. - Reduced vibrations, leading to less wear and tear.
Compressor (including motor)	IV) Where the compressor package is older than 10 years.	Replacement of outdated compressors with efficient models including energy recovery systems.	- Improved process reliability and uptime. - Reduced noise pollution. - Lower maintenance costs due to newer technology.
Motor Pump Fan Compressor Machine	V) Not turned off (or down) during low (process) load or idle periods and continue running regardless of process demand.	Proper control of the systems to turn off unused motors, pumps, fans, compressors and machines and remove unnecessary bypasses.	- Increased productivity through more efficient process control. - Extended equipment life by reducing unnecessary usage. - Improved process stability through better load control.
Motor Machine	VI) Not adjusted to changing functional requirements (compared to the design), causing underloaded operation (low load, <60%).	Adjust or replace the machine with a high-efficiency model and properly tune power, frequency, flow and controls to match demand; check periodically.	- Better alignment with process requirements for increased flexibility. - Less wear and tear, leading to less downtime and lower maintenance costs. - Improved reliability and lifespan of the motors.
Pump Fan Compressor	VII) Not adjusted to changing functional requirements (compared to design), resulting in insufficient operating hours near the optimal working area/BEP (best efficiency point).	Optimize or replace components to better align with the optimal working area (BEP).	- Improved system performance by operating in the optimal range. - Lower repair and maintenance costs. - Reduced unexpected failures, leading to higher production efficiency.
Motor Pump Fan Compressor Machine	VIII) Having inefficient components and/or settings, such as throttling valves, vanes, inefficient transmissions, bypasses, (parts of) piping with high flow resistance.	Replace and/or adjust one or more components of the drive systems, for example, remove throttling and apply speed control, use a high-efficiency transmission, apply direct drive with speed control and modify piping.	- Reduced mechanical wear through optimization. - Less downtime due to failure through better adjustment. - Improved system control, leading to higher product quality and process safety.

Feedback received

Including non-energy benefits (NEBs) in the audit template could enhance the appeal of motor replacement to company decision-makers and support energy advisors in better "marketing" these energy efficiency measures.

However, while this suggestion could be useful, it would impose an additional burden without delivering significant benefits. The advisors carrying out the investigation would probably copy the NEBs of similar systems in the report, without verifying the occurrence of such benefits.

Initial Recommendation #5 – Adjusting the current Energy Investment Allowance (EIA) scheme to reduce free-riders risk

Consider a lower deduction rate (e.g., 30-35%) to reduce the free riders while maintaining the scheme's attractiveness for energy efficiency investments.

Feedback received

Reducing the deduction rate would not effectively address the issue of free riders. This issue is also not perceived as a major hurdle by RVO.

Final recommendations

Final Recommendation #1: Strengthen Knowledge-Sharing and Improve Energy Audit Effectiveness

Instead of launching a full-scale capacity-building program, focus on structured knowledge-sharing initiatives for energy audits. These initiatives should:

- Enhance the quality and consistency of audits by promoting best practices, including examples of Non-Energy Benefits
- Encourage a step-by-step compliance approach, ensuring companies move from audits to concrete efficiency improvements.
- Emphasize overall system efficiency rather than just motor replacement, recognizing that companies are aware of inefficiencies but often lack incentives to act.
- Maintain targeted subsidies for SME audits, but avoid unnecessary support for large companies already subject to audit obligations

Final Recommendation #2: Explore Alternative Financial Metrics While Addressing Investment Trade-offs

- The payback period (PBT) threshold should be extended beyond five years, while ensuring it does not force businesses into inefficient capital allocations.
- Alternative financial metrics, such as Internal Rate of Return (IRR), should be explored further to assess energy-saving obligations, but they must align with companies' investment priorities.

Final Recommendation #3: Promote the development of Company-Level Motor Inventories and Recycling of Inefficient Motors

To improve industry awareness and efficiency in motor use:

- Companies should establish **in-house motor inventories**, ensuring better tracking of in-use motors and their energy consumption.
- Encourage companies to phase out stockpiling of outdated motors by discouraging repairs of motors beyond a certain age and promoting their recycling instead.
- Introduce **scrappage schemes for recycling old motors**
- Support industry-driven demand for efficient motors by aligning efforts with broader climate and energy goals.

7. Conclusions

The transition to high-efficiency electric motors is crucial to reduce energy consumption, lower greenhouse gas emissions and enhance industrial competitiveness. This report highlighted the key barriers to a fast and widespread adoption of those state-of-the-art motors, including high upfront investment costs, lack of awareness and technical expertise, and the complexity of funding processes. Nevertheless, a range of policy solutions that can speed up motor replacement are available, such as financial incentives, EEOS, voluntary agreements and capacity-building initiatives.

A combination of financial support mechanisms, regulatory frameworks, and awareness-raising programs will be essential to drive the replacement of old and inefficient electric motors.

Tailored national strategies, as outlined for Austria, Germany, Greece, Portugal, and the Netherlands, demonstrate the need for country-specific approaches that align with existing policies and industrial contexts. Best practices from various EU Member States provided valuable insights into effective policy design, emphasizing the importance of long-term programs, improved monitoring and verification systems, and stronger collaboration between policymakers, industry stakeholders and financial institutions.

Emphasis should be placed on integrating circularity aspects into the policy design. The lifecycle impact of electric motors extends beyond the use-phase energy consumption, and involves resource extraction, manufacturing, and end-of-life disposal. Ensuring that motor replacement programs align with circularity objectives will maximize environmental benefits while minimizing resource consumption.