March 2025

EU-MORE

EUropean MOtor REnovation initiative

Deliverable D6.2 – Replication of Policies

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Co-funded by the European Union

Revision History

Version	Status	Public/ confidential	Comments	Contact
V1.0	Draft	Confidential		Konstantin Kulterer (AEA)
V2.0	Final	Public		Konstantin Kulterer (AEA)

EU-MORE is an acronym for
EUropean MOtor
REnovation initiative

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Executive Summary

As part of Work Package 6, we analysed the possibilities of replicating the developed policies for replacing electric motors to other, related products categories where similar barriers to the accelerated uptake of more efficient units are identified. These product categories include, among others, pumps and fans, transmission systems (gear, belt-drive), and entire cooling systems and air compressors. We analysed existing programmes aiming to directly or indirectly stimulate the uptake of more efficient units in these product categories and calculated the potential impact of replacing older units.

Programmes already identified in the EU-MORE Review of Past and Existing Policies for the Acceleration of Electric Motor Renovation (D2.2) [1] are further analysed, with a focus on elements of motor driven systems (pumps, fans, air compressors, chillers). To this, the analysis added similar programmes that were not tackled by the EU-MORE motor policy review. We identified programmes for motor driven systems (such as compressors, pumps, or fans) in 14 countries. They cover the full range of policy instruments, from awareness raising activities and trainings, over audit programmes, to financial incentives and white certificate schemes.

Table 1: Programmes covering motor driven systems

Types of programmes	Examples analysed in this report
Awareness raising, training	Austria, Switzerland, Compressed Air Challenge
Audit programmes with connection to motor driven systems	Austria, Denmark, Netherlands, Portugal (in combination with mandatory implementation of saving measures), Motor Challenge Programme
Tax incentives	Netherlands, Sweden
White certificates	France, Italy
Subsidies	Austria, Bulgaria, Germany, Greece, Portugal, Slovenia, Sweden, Switzerland
Subsidised loans	Germany, Slovakia
Energy saving obligation	Netherlands
Mandatory monitoring of major energy consumers	Hungary, Germany (in combination with subsidies)

Methods for incorporating motor driven systems in these programmes and other key observations were summarised. Here are some of the most important observations:

- For several countries, it is common to define which technologies and saving measures are covered by the programme. Several programmes define, for example, the minimum efficiency of pumps, fans, and air compressors for which subsidies or other financial incentives can be granted.
- Some programmes also include a transmission system or subsidise direct drive fans.
- Some programmes explicitly include measures for the output-side of motor driven systems, e.g. for the insulation of cooling chambers.

- In at least one country (Hungary), it is mandatory to measure the energy load of motor driven systems (e.g. compressors) having a power rating that is above a certain minimum value. Doing so can raise awareness about the energy costs associated with the system.
- Several countries have published guidelines or formulas for energy auditing of motor driven systems and/or the energy saving calculation for energy saving measures in this field.
- Some countries have developed a complete portfolio of awareness raising and training material for all major types of motor driven systems.
- Several incentive programmes include not only the costs of equipment, but also other costs associated with the installation, such as costs for engineering and energy audits.
- For most incentive programmes, it is mandatory to measure the energy consumption after the implementation of the measure.

The appropriateness of each of the policy recommendations formulated in D2.3 (EU-MORE Policy Recommendations for Electric Motor Renovation [64]) was checked and adapted for the systems under consideration, where relevant. Important recommendations include:

1. Initiate a data collection programme
   Collect baseline data, e.g. through energy audits, on motor stock and on the applications those motors are driving (e.g. pumps, fans, compressors, conveyors), including nameplate data such as power rating (rated flow and pressure if applicable) and energy efficiency, as well as age and load characteristics (variability and average value).

2. Initiate a subsidies scheme for motor system investments
   Several programmes already include improvements in pumping, ventilation or compressed air systems on top of motor optimisation measures. For specific technology programmes, e.g. for chillers, several elements can be described in more detail, e.g. which technologies and equipment are subsidised, which measures are compulsory, and which are optional, and which data must be reported, measured or calculated after the implementation of the measure.

3. Initiate a tax incentives scheme combined with Voluntary Agreements for "low-hanging fruits"
   Within the catalogue of applicable measures for the tax incentive scheme, the main measures for the optimisation and replacement of all motor driven systems should be included.
   For Voluntary Agreement Schemes, it is important to include training and awareness raising measures directed to auditors, consultants and the companies that provide information on the saving possibilities and technologies in motor driven systems. Furthermore, the scheme could include minimum standards for new equipment that exceed the minimum performance standards of the related Ecodesign directive. It could also include a mandatory inventory list for all motor driven systems above a certain power level.

4. Update the established Energy Efficiency Obligation Scheme to indirectly finance energy audits
   When implementing the programme, clear guidelines for the auditing of motor driven systems must be given.

5. Provide free energy audits and capacity-building activities for SMEs
   Auditors must be trained in analysing motor driven systems. The audit should not only cover what is in the motor inventory, but also assess the major energy saving measures in the motor driven systems.

6. Initiate an information and capacity-building programme
   Optimising systems such as compressors requires a broad knowledge of its different components and its physics. It is therefore useful to organise separate training courses for each of these systems.

Another part of this report deals with the calculation of the expected saving effects of replacing pumps, fans, and compressors at a detailed level, focusing on energy effects. In 2023, pumps, fans, and compressors in EU-industry were responsible for around 412 TWh of electricity consumption [57]. The potential electricity savings from replacing outdated equipment with more efficient models are significant. Assuming that 50% of equipment has exceeded its operational lifetime, early replacement of inefficient equipment could yield average annual savings of approximately 29.8 TWh. Similar to the case of electric motors, the savings from addressing the entire system (e.g. variable speed operation, oversized equipment, minimise unnecessary bends, leaks, and pressure drops, implement real-time monitoring with sensors to detect inefficiencies, etc.) would be much larger compared to looking at one component only. Evaluating potential measures at system level at the time of replacement is therefore recommended.

1. Indroduction and methodology

This report analyses the possibility of replicating the EU-MORE policies to other elements in motor driven systems with similar barriers to the uptake of more efficient products, for example the replacement of the pump, the fan, or the transmission system (gear, belt-drive) or the replacement of cooling and air compressors.

Existing programmes covering these topics will be analysed and expected effects will be calculated on a more thorough level than done for the electric motor market.

In a first step, policy programmes already analysed in the EU-MORE Review of Past and Existing Policies for the Acceleration of Electric Motor Renovation (D2.2) [1] that at least mention one motor driven system (pumps, fans, air compressors, chillers) are described, with additional information on the systems mentioned where applicable. Policy programmes that are not mentioned in the EU-MORE policy review but do focus on motor driven systems are also described. Some major observations from the assessment of all these programmes will be provided. In a second part, the general (not country-specific) EU-MORE policy recommendations are analysed for the possibility to replicate them for these products.

The third part is the calculation of the expected impact, focusing mainly on energy effects.

2.1 Definitions

Motor Driven Unit

The motor driven unit (MDU) comprises the electric motor, control equipment such as a relay, soft starter, or variable frequency drive (VSD), supporting mechanical equipment (e.g. direct coupling, gears, belts, clutches, brakes, ...), and the driven application (e.g. pump, fan, compressor, conveyor).

All these elements together are often called "the motor driven system", ignoring the fact that there are more elements in the system that also have energy losses. Here, we will define the "motor driven system" more broadly, including also the power supply equipment on the input side, and the mechanical controls and process components (e.g. pipes, ducts, valves, throttles, and dampers) on the output side. If present, each of these parts of the system will have losses that collectively determine the overall system efficiency. Therefore, achieving the highest efficiency for each of these components under diverse operating conditions is crucial for attaining the maximum efficiency. [2]

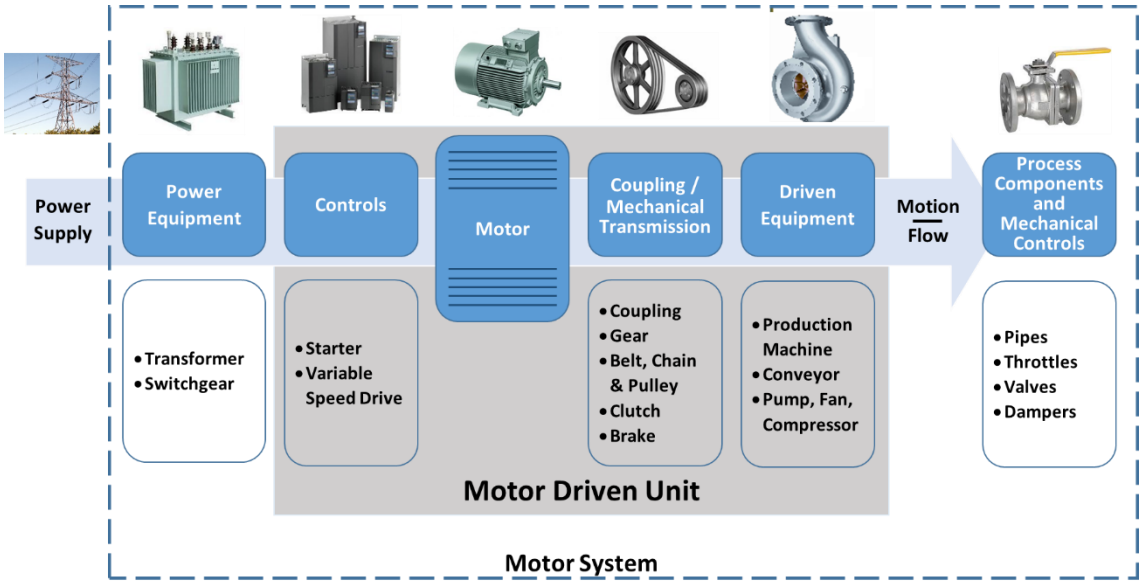

Figure 1: Example of motor system including Motor Driven Unit [2]

Each part of the system should be given careful consideration as a source of potential losses: power supply quality (high-quality power supply), careful attention to harmonics and voltage unbalance, system oversizing (proper equipment sizing), the transmission and mechanical components (optimised transmission systems), the match between the load (torque-speed requirements) and the motor (good load management practice).

Motor Driven System

Another approach to motor driven systems is given by the ISO 11011 Standard Compressed air – Energy Efficiency – Assessment [3]. Some definitions of this standard are presented in this subsection.

ISO 11011 defines the assessment of a compressed air system as follows:

"Activity which considers all components and functions, from energy inputs (SUPPLY SIDE) to the work performed (DEMAND SIDE) as the result of these inputs; undertaken to observe, measure, and document energy reduction and performance improvement opportunities in a compressed air system." [3]

The supply side is defined as "conversion of primary energy resource to compressed air energy" and the demand side as "total of all compressed air consumers, including productive end-use applications and various forms of compressed air waste". [3]

Compressed air being wasted should be identified as leakage, inappropriate end use, and artificial demand.

Inappropriate end use is defined as: "The processes can be identified as inappropriate if a more energy-efficient alternative technology makes the use of compressed air unnecessary." [3]

The definition of "artificial demand" is: "excess air consumed by a system's unregulated or poorly regulated uses due to operating at a pressure in excess of actual requirements". [3]

This means that many other technologies besides the motor-driven unit must be taken into account when evaluating a compressed air system, especially on the demand side. For example, replacing air-powered hand tools, the applying compressed air for cooling, or optimising nozzles can be relevant actions for optimising the compressed air system.

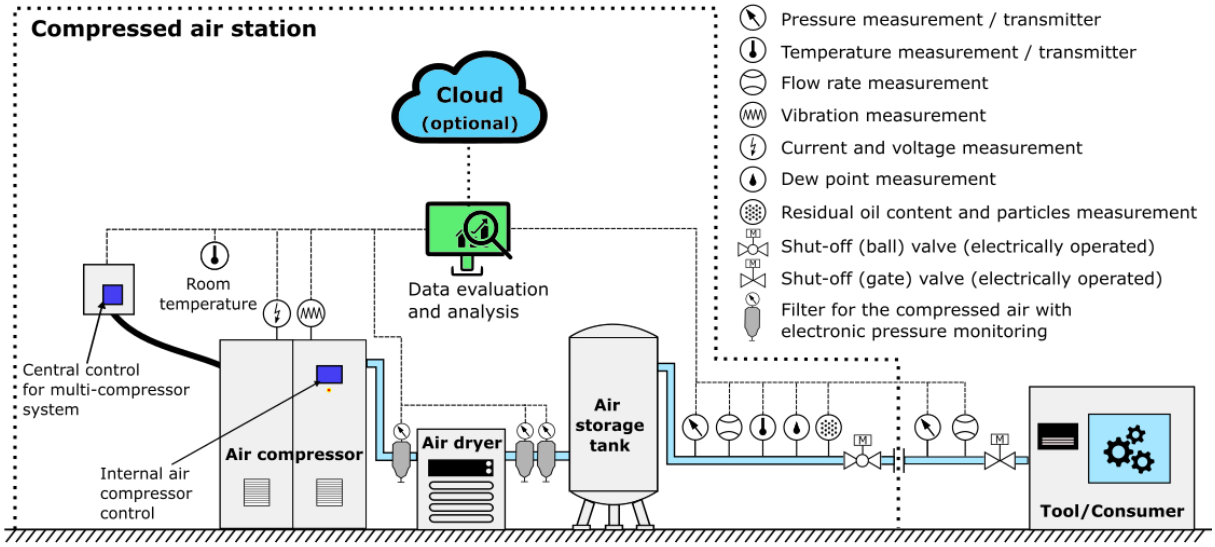

Figure 2: Example of motor a system: a compressed air system [6]

Similarly, for other systems such as ventilation or pumping systems, demand-side optimisation measures should be considered, such as pipe cleaning in pumping systems, regular filter changes in ventilation systems, or optimised control of industrial washing systems (only spray water when products are in the line).

These issues are not easily addressed by standards or regulations at the product level.

Measures to improve motor driven systems, including the demand side, should in principle be taken in the context of the following two standards, even though this might not always be the case in practice:

- EN 16247-3. The energy audit series EN 16247-3 for processes contains the requirement for energy auditors to include measures such as the reduction of energy losses through a more efficient operation. Annex B of this standard lists several important parameters and data to be collected for equipment like chillers, pumps, fans, and air compressors. [3,4]

- ISO 50001. As part of the implementation of energy management systems according to ISO 50001, the energy use must be evaluated, criteria for the effective operation of equipment and systems must be defined and action plans to improve the energy performance of a company must be developed. [5] "The organization shall consider energy performance improvement opportunities and operational control in the design of new, modified and renovated facilities, equipment, systems and energy-using processes that can have a significant impact on its energy performance over the planned or expected operating lifetime." (8.2, ISO 50001, [7])

2. Existing Policy Analysis

This section describes in more detail the policy measures identified in the EU-MORE policy review [1] that include motor-driven systems in their scope, with a focus on elements of motor-driven systems (pumps, fans, air compressors, chillers).

The analysis also includes other, similar programmes that were not identified by the EU-MORE policy review.

The final section summarises, for each type of programme, approaches for incorporating motor driven systems into such programmes.

2.1 Austria

In Austria, the energy efficiency legislation [8, 10], which implements the European Energy Efficiency Directive (EED), specifies the following elements for mandatory energy audits, among others. Energy audits must identify and analyse:

- The main energy consuming factors and energy conversion equipment based on energy, fuel or fuel bills, sub-meters, calculations, or measurements (energy balance); energy consuming factors are also devices that are mainly responsible for energy consumption within a significant energy consumption range.
- Relevant impacts on energy consumption, in particular on the main energy-consuming factors and energy conversion systems.
- Relevant energy performance indicators, including their development over time.
- Relevant measures to increase energy efficiency. They must include, for the main areas of energy consumption, the annual energy savings potential per measure in kWh, the investment costs, and the annual energy cost savings in the main energy consumption areas.

The following additional activities must be implemented during the energy audits of production processes:

- Recording and analysing significant energy-relevant production and equipment processes (these include, as explained in the explanations to the law, major relevant motor driven systems as compressed air, refrigeration compressors, internal conveyor belts, lifting and crane systems, pumps, fans, and ventilation systems)
- Examination of replacement, modification or upgrading of equipment
- Examination of company-specific measures that ensure more efficient operation, ongoing optimisation and improved maintenance

The energy consumption of the selected main energy-consuming factors should in total account for at least 80 % of the total energy consumption of the respective company.

According to the minimum requirements for the energy audit reports of mandatory energy audits, the energy consumption of the following motor driven systems must be measured or calculated [9]:

- Ventilation and cooling for buildings
- Process cooling, compressed air and mechanical work for processes (e.g. drilling machines, mixing equipment, or mills)

To summarise, motor driven systems are covered by several stipulations in several legal documents implementing the energy audit requirements for bigger companies, although most of them do not explicitly mention the motor system data that need to be collected.

Within the EU-MORE project, the national subsidy programme "Energy-saving measures in enterprises" [11] plus two other programmes (on air conditioning and cooling, and on energy centres) within the same framework were analysed for the period 2018–2022. A total number of 2.490 projects were funded of which 371 projects were motor related. Out of these projects, 162 focused on compressed air system optimisation (incl. for example new compressors with VSD-control), 86 projects on pumping system optimisation, three projects on fan optimisation, and two projects on transmission system optimisation.

The funding rate within these programmes is maximum 30% (for SMEs up to 35%) of the total investment cost, and the funding is limited to 750 euros per tonne of CO_2 saved or avoided.

The analysis showed that often the replacement of entire component groups with integrated motors (e.g. pumps, compressors, etc.) were subsidised. However, there are no specific minimum efficiency criteria for the different product groups.

Another programme, the "klima**aktiv** Energy Efficient Enterprises", supports industrial and commercial enterprises in optimising their energy efficiency. The main elements are [12]:

- Trainings and webinars for businesses and energy consultants
- Information and contacts for subsidised business consultations
- Guidelines, fact sheets and assessment tools on operational energy efficiency measures
- Posters and videos to raise awareness among employees
- Networking and exchange for implementing energy efficiency measures

The klima**aktiv**programme, the national climate initiative of the Federal Ministry for Climate Action in Austria, cooperates with market-partners for specific technologies, e.g. compressed air, variable speed drives, pumps, fans, lighting systems, steam systems, and waste heat to meet the need of companies for highly detailed and professional support. Information on advanced technologies is spread via newsletters and trainings. By 2022, approximately 1,000 consultants have been trained in using tools for energy audits and about 300 companies have been awarded by the Minister of Environment for implementing energy efficiency measures. [12]

Regarding energy audit guides, the technological approach of the programme has been dedicated largely to motor driven systems. Since 2008, specific PR-materials, tools, and a training concept for consultants for different technologies have been developed (compressed air, pumps, fans, steam, cooling systems, lighting, and waste heat, machine tools). In 2015, the programme emphasised the different possibilities to meter energy and calculate energy savings. For all technologies, the most relevant saving measures are described for a quick on-site evaluation. For the evaluation of all measures, the necessary data to be collected is stipulated, and rough economic and technical criteria are developed to decide if and how a specific technology component should be improved. Furthermore, a standard report has been developed. Consultants and energy managers are trained with this tool and use it to audit their company or customers.

As an example, the compressed air audit guide includes the following chapters [13]:

- Data collection, electricity consumption measurement
- Measure 1: Reduction of leakages
- Measure 2: Optimisation of the grid pressure
- Measure 3: Improving the control system
- Measure 4: Reduction of the proportion of no-load operation
- Measure 5: Heat recovery
- Measure 6: Switching off the systems and consumers
- Measure 7: Optimisation of consumers

The number of participants who successfully completed the training programmes (2008–2022) was:

- 279 – for compressed air systems training
- 289 – for pump systems training
- 222 – for ventilation and air conditioning training

2.2 Bulgaria

In Bulgaria, "Innovations and Competitiveness" (OPIC) is the main programme that provides support to businesses through the European Structural and Investment Funds (ESIF) for the period 2014-2020. [14]

One of the project selection procedures of OPIC is **"rebuilding SMEs by improving energy efficiency" - BG16RFOP002-6.002**. The total budget for the project is BGN 136 million (EUR 70 million). The minimum project size is BGN 25,000 (EUR 12,800) and the maximum is BGN 150,000 (EUR 76,850), with a maximum funding rate of 50 %. [14]

The following text describes the criteria for selecting a project [14].

Eligible candidates:

- Micro, small, or medium-sized enterprises registered under the Commercial Act or the Cooperative Act
- Candidates who have concluded financial years in 2018, 2019, and 2020
- Candidates engaging in their primary economic activity in sector C "Processing Industry" according to the Classification of Economic Activities (CEA-2008)

In this regard, candidates can:

- Fund the acquisition of a new energy monitoring system, using funds from the current procedure, including such expenses in the project
- Fund the upgrade of an existing energy monitoring system to cover the energy consumption of the materials and equipment acquired through the project, using funds from the current procedure, including such expenses in the project

It is permissible to purchase technology/equipment through this procedure.

Therefore, the list of eligible categories of materials and equipment includes possible expenditures for the acquisition of machinery, facilities, equipment, systems representing durable assets, and materials.

When choosing technology/equipment from the list, candidates may include auxiliary materials and equipment necessary for their assembly and/or commissioning as functional units. Furthermore, for all investments in materials and equipment from this list, beneficiaries are required to annually provide energy consumption data for a period of three years after project completion. [14]

These equipment groups are established based on the following criteria: [14]

- New energy-efficient systems and equipment available on the Bulgarian market.
- New energy-efficient systems and equipment based on best available techniques (BAT).
- Operational characteristics compliant with national standards and regulations.
- Compliance with European and/or Bulgarian standards (e.g., DIN, ISO, CE marking, etc.).

For pumps, the following additional criteria were defined for the programme duration until 2020: [14]

- Standard for energy efficiency of the motor: IE3 or IE4
- Minimum energy efficiency index (MEI) ≥ 0.70
- Minimum efficiency index (IEE) for circulation pumps ≥ 0.20
- Built-in electronic control
- The minimum measurement points for the monitoring include a power meter for each pump or group of pumps with a common power supply line and a total installed electrical power above 15 kW.

For compressed air, the following criteria are defined:

- Energy efficiency standard for the main motor with nominal power 2–18 kW: ≥ IE3
- Energy efficiency standard for the main motor with nominal power 19–75 kW: ≥ IE4
- Operating pressure: 7.5–13 bar

Piston compressors:

Up to 10 bar: 7.3–10.3 kW/m^3/min

10–15 bar: 8.7–13.0 kW/m^3/min

Rotary compressors:

Up to 7.5 bar: 2–18 kW: 6.2–8.2 kW/m^3/min

19–75 kW: 5.4–6.3 kW/m^3/min

7.5–10 bar:	2–18 kW: 7.3–10.3 kW/m^3/min
	19–75 kW: 6.4–7.2 kW/m^3/min
10–13 bar:	2–18 kW: 8.7–13.0 kW/m^3/min
	19–75 kW: 7.8–8.8 kW/m^3/min

As a minimum measurement point, a power meter for each new compressor is stipulated.

In Bulgaria, the Energy Efficiency and Renewable Sources Fund (EERSF) is an entity that combines the functions of a lending institution, a credit guarantee facility, and a consulting company.

A necessary condition for a successful application with the EERSF is a detailed energy audit allowing for an energy analysis and choice of energy saving measures.

The financial resources of the fund can be used to finance different types of investment, incuding the replacement of air compressors.

2.3 Croatia

In Croatia, the integrated national energy and climate plan (NECP) includes 18 energy efficiency measures. These include the energy efficiency obligation system for suppliers and seven other measures which are linked to the savings of the European Energy Efficiency Directive (EED) Article 8. [15]

Precise information on which actions are eligible for industry is available in the ordinance on the system for monitoring, measuring and verification of savings (OG 98/2021). It includes the use of efficient compressors and the use of energy efficient pumps in industrial processes.

2.4 Denmark

In Denmark, large companies are required to conduct energy audits every four years under the EU's Energy Efficiency Directive. Companies with more than 250 employees or a turnover of at least 50 million euros must comply. Reporting the audit results to the Danish Energy Agency is mandatory, but the implementation of energy-saving recommendations is not required. The policy measure does not specify the replacement of inefficient electric motor systems, but does not exclude it as a potential action following from the energy audits either. [1]

There are no requirements to actually implement the recommendations from the energy audit. Denmark has carried out an ex-ante analysis on the economic consequences for the enterprises. The analysis states that the administrative burdens for the enterprises will be approximately DKK 44.3 million (EUR 5.9 million) annually. [1]

In 2020, almost 2,100companies were required to carry out mandatory energy audits, and 1,100 companies were required to do so in 2021. [16]

The areas with the greatest opportunities for energy savings and efficiency improvements are primarily in lighting and energy management technologies. These sectors have significant potential for reducing energy consumption and optimising energy usage.

Additionally, there are substantial opportunities for energy savings in ventilation and cooling systems. By implementing more efficient and optimised ventilation and cooling solutions, businesses and industries can further reduce their energy usage and overall environmental impact.

The following graph shows the identified energy saving potential in GWh/a for different technologies. Motor systems mentioned in the graph include "ventilation", "pumping" and "trykluft" (meaning compressed air).

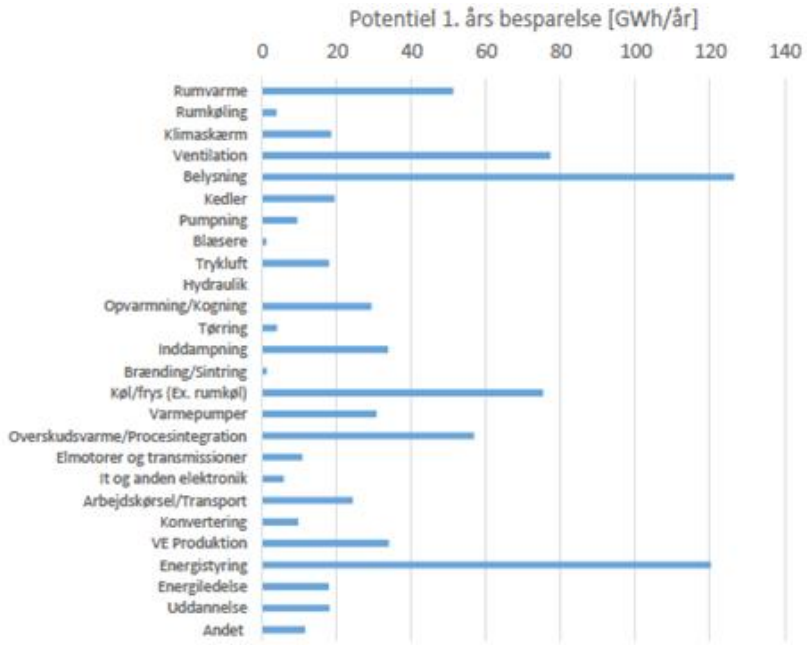

Figure 3: Analysis of Danish energy audits: Energy saving potentials identified [17]

As mentioned, implementing the energy saving improvements recommended by the energy audits are not mandatory. This may explain why no data are available on actual realised energy savings. [1]

2.5 France

The white certificate scheme in France was created by the national Energy Law, which was adopted in 2005 and officially started in July 2006. It sets mandatory energy saving targets for energy suppliers. They can meet their targets by acquiring white certificates, either with their own programmes or by buying them on the market. The most common way to get certificates is to use the catalogue of the 200+ types of standardised actions (88% of the white certificates in 2018-2021). It is also possible to get certificates from specific actions reported by energy audits (3.6%) or by funding accompanying programmes selected by the ministry through calls for programmes on topics defined by the ministry (8.4%). [24]

The standardised actions are defined by technical specifications (e.g. minimum efficiency requirements, capacity range, installation by a professional, applicable technical standard(s) to be met). These specifications also set the data to be reported for each action. The fact sheets of the specifications (in French) are given below with the catalogue's code of each action type. [24]

List of standardised actions related to electric motors (as of July 2023), with their code in the catalogue:

ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie

Most of these action types are for industry:

- IND-UT-132: asynchronous motor of class IE4
- IND-UT-102: variable speed drive on asynchronous motor
- IND-UT-114: permanent magnet or reluctance synchronous motorised variable speed drive
- IND-UT-133: electronic control system for an electric motor with energy recovery
- IND-UT-136: motor-controlled systems

There are also two action types for the service sector:

- BAT-EQ-123: permanent magnet or reluctance synchronous motorised variable speed drive
- BAT-TH-112: variable speed drive on asynchronous motor

The following action types are defined for other motor systems:

- IND-UT-103: air compressor heat recovery system
- IND-UT-115: low-pressure floating control system for chillers
- IND-UT-116: control system for a refrigeration unit with floating high pressure
- IND-UT-120: low-pressure screw or centrifugal air compressor
- IND-UT-135: free cooling by cooling water in substitution of a chiller unit

For these actions, a fixed formula is defined for calculating the energy savings in kWh, usually per kW of installed power, plus the number of shifts in which the company operates.

2.6 Germany

The website of KfW Bank (kfw.de/inlandsfoerderung/Unternehmen/Energie-und-Umwelt/), that is responsible for subsidies and subsidised credits for energy saving measures in Germany, shows the main saving opportunities in all motor driven systems (motors, pumps, fans, compressed air and cooling systems) on the home page. [18]

The Federal Funding for Energy and Resource Efficiency in the Economy (EEW) is the central government programme of the Federal Ministry for Economic Affairs and Climate Action (BMWK) to increase energy efficiency in industry. It receives over 10,000 applications per year.

The funding programme consists of different modules.

The purpose of module 1 is to support the **replacement or acquisition of high-efficient units for industrial and commercial applications** on the company premises in the following cross-sectional technologies [19]:

- Pumps with electrical drive – highly efficient centrifugal and dry rotor pumps, wet rotor circulation pumps, frequency converter for pumps with variable flow rate. Pumps must be driven by a highly efficient electric motor, which means efficiency class IE4 or higher.
- Fans – highly efficient fans that use an electric motor to drive a rotating impeller, frequency converters for demand-dependent control of the fan speed, and heat exchangers.
- Compressed air generators – with speed control, or without speed control if the compressor operates with low switching frequency and low idle time.
- Frequency converters for demand-dependent speed regulation of electric motors and drives.

For all technologies, very specific criteria are given, including minimum efficiency requirements for pumps, fans, and air compressors. These minimum requirements are based on the parameters and criteria defined within the European Ecodesign Regulations for these products, with higher benchmarks than the minimum requirement within these regulations. [19]

The maximum amount of subsidy is EUR 200,000 per beneficiary for module 1 (cross-cutting technologies). The funding rate is 30 % of eligible costs, 40% for small and medium-sized enterprises (SMEs). [19]

Module 4, part of the funding programme "Federal Funding for Energy and Resource Efficiency in the Economy" supports investment measures for energy-efficient optimisation of systems and processes in industrial and commercial companies. [20]

The funding programme offers two options: a grant variant and a repayment subsidy alongside a loan. The BMWK considers these funding options to cater to the diverse financing needs of businesses. The technical minimum requirements are the same for both variants. The maximum funding amount is EUR 10 million, with a funding rate of up to 30% of eligible investment costs (40% for SMEs). Under the loan variant, projects can be financed up to EUR 25 millions of eligible investment costs. [20]

Electric drive systems (motors, pumps, fans, HVAC systems) represent around 36% of all the funded projects. [20]

Eligible measures for funding include [20]:

- Process optimisations or changes for energy and resource savings
- Utilisation of process waste heat, such as capturing and using it in heating networks or generating electricity
- Increasing energy and/or resource efficiency in heating, cooling, and ventilation systems used in manufacturing
- Efficient provision of process heat or cooling, including optimised storage
- Avoiding energy and/or resource losses in production processes.
- Shifting from fossil fuels to renewable energy sources
- Electrification of processes

The maximum amount of funding is EUR 500 per tonne of CO_2 saved annually (max. 900 EUR per tonne of CO_2 for medium-sized companies, and max. 1,200 EUR per tonne of CO_2 for small enterprises) The funding rate is 30 % of eligible costs, and 40% for small and medium-sized enterprises. [20]

The assumed lifetime for energy saving measures is 7.8 years on average The individual lifetime depends on the measure (electrical drives, compressed air, systemic solutions, pumps: 8 years)

Another programme, the **KfW Energy Efficiency Program for Production Plants and Processes** (KfW 292/293), supports commercial enterprises in implementing energy efficiency measures with low-interest loans (interest rate from 3,03%, January 2025). [21]

The funding programme is available for companies of any size. Funding is available for all investment measures that achieve greenhouse gas savings of at least 15 %, for example in the areas of: [21]

- Energy-efficient systems and process technology
- Compressed air/vacuum/extraction technology
- Electric drives/pumps
- Electrification of processes
- Process cooling, cold stores, cold rooms
- Heat recovery / waste heat utilisation
- Measures for CO_2 capture
- Systems for the utilisation of hydrogen
- Digitalisation measures to increase energy efficiency
- The maximum funding per project is EUR 25 million
- Up to 100% of eligible costs can be financed.
- The credit limit can be exceeded if the project has special eligibility for funding.

In Germany, a **funding programme dedicated to commercial users of refrigeration systems** is available. The following are the most important specifications in English: [22]

Funding is available for measures to increase the energy efficiency of stationary refrigeration and air conditioning systems that use non-halogenated refrigerants. This also includes the installation of system components (e.g. heat pump for waste heat utilisation or storage tanks), provided that energy efficiency can be further increased. The eligible measures concern the installation of systems, their retrofitting and conversion, and the efficiency conversion of small systems. In detail, the funding covers:

- Installation of the refrigeration unit of stationary refrigeration and air conditioning systems and of recooling systems
- Liquid cooling units and direct evaporation systems
    - Absorption and adsorption systems (excluding components and systems for free cooling operation)
    - Refrigeration units with indirect evaporative cooling or with adiabatic cooling in recoolers and dry coolers
    - No funding is available for cooling generators, including the associated components and systems, that are used primarily to cool sales cooling units, as well as plug-in sales cooling units.

- Installation of stationary heat pumps to utilise waste heat. The use of process waste heat for heating purposes in a separate heating system or for a process engineering procedure is a funding requirement.
- Retrofitting dry coolers as pre-coolers or free coolers – Funding is available for retrofitting dry coolers as pre-coolers or free coolers.
- Installation of components and systems (only in conjunction with funding for the installation of a refrigeration unit)
    - Freezing stages
    - Air coolers and dry coolers
    - Thermal storage
    - Pipelines of cooling brine circuits
    - Components for waste heat utilisation of the refrigeration system and for heat pump operation
    - Components for free cooling operation and retrofitting of control and regulation technology for pre-cooling and free cooling operation
    - Integration of systems for the use of renewable energies
- Efficiency retrofitting of small systems

The following retrofitting and conversion measures are subsidised for existing small compression refrigeration or air conditioning systems with fluorinated refrigerants:

Compulsory measures:

- Conversion to a hydrocarbon refrigerant with a minimum filling quantity of 0.5 and a maximum of 10 kg
- Installation of a pressure-controlled speed controller for the condenser fan to reduce the condensing pressure of the system at low ambient temperatures

Optional measures:

- Installation of an electronic expansion valve
- Installation of an inverter for compressor speed control
- Installation of an internal heat exchanger or contact between the suction line and the liquid line

An online funding calculator calculates the amount of possible funding in EUR based on the current funding guideline. To do so, the calculator asks for parameters and values that are relevant for the calculation, such as the type and cooling capacity of the refrigeration system and the type and capacity of the components of a refrigeration or air conditioning system. In addition, funding for thermal storage, heat pump operation, waste heat utilisation, pre-cooling and free cooling operation, and the integration of a system for the use of renewable energies can be determined. In the last step, the results are displayed in tabular form.

For efficiency upgrades of small systems, flat-rate amounts are granted that depend on the diameter of the suction line. For optional efficiency retrofitting measures, the amount of the flat rate depends on the type of measure.

The BAFA (German abbreviation for Federal Office for Economic Affairs and Export Control) Efficiency Check for refrigeration and air conditioning systems must be carried out for compression refrigeration or compression air conditioning systems with an electrical power consumption of 20 KW or more. The execution must be proven by the results protocol.

For compression refrigeration or air-conditioning systems with an electrical power consumption of up to 20 kW, the BAFA Efficiency Check is not a requirement for funding, but can be carried out as an option.

Proof of use

For proof of use, the applicants prove that they have carried out the measure as approved, met the deadlines and fulfilled the conditions. Among other things, it queries technical parameters of the installed refrigeration or air conditioning system and its components. In addition, the following documents must be attached to the proof of use in electronic form:

- Filled out electronic proof-of-use form (online proof-of-use portal)
- Flow chart of the system installed
- Proof of efficiency for the system installed (only for compression refrigeration or air conditioning systems with an electrical power consumption of 20 kW or more), using the BAFA Efficiency Check for Refrigeration and Air Conditioning Systems
- Proof of commissioning of the integrated system for the use of renewable energies (if applicable)
- Supply and service contract
- Acceptance report
- Specialist company declaration
- Maintenance contract or proof of in-house maintenance
- Invoices for the eligible expenses
- Notice of installation of an electric energy meter with details of the commissioning date (only for compression refrigeration and compression air conditioning systems with an electrical compressor capacity of 5 kW or more, with remote reading from 15 kW electrical compressor capacity)
- Proof of the installation of a cooling meter (only required for liquid cooling units and sorption systems with a cooling capacity of 20 kW or more, and with a remote-readable cooling capacity of 50 kW or more)

For systems that have been retrofitted for efficiency, the following documents must be submitted:

- Fully completed proof-of-use form (online proof of use portal)
- Supply and service contract
- Specialist company declaration for efficiency upgrades (form from the licensing authority)
- Invoices for the eligible expenses

The technical parameters must be confirmed by the respective specialist company (= refrigeration system installer). For this purpose, the portal generates a separate declaration for each specialist company involved in the installation of the refrigeration or air conditioning system. This declaration refers to exactly those components of the refrigeration or air conditioning system that were installed by the respective specialist company. The applicants or their authorised representatives should forward the relevant declaration to each specialist company with the request to complete, sign and stamp it. The signed specialist company declaration must then be submitted to BAFA via the upload area. [22]

Monitoring

Each recipient of funding is obliged to provide BAFA with certain information on the operation of the system for regular monitoring once a year over a period of three years starting from the date of acceptance of the funded refrigeration or air conditioning system.

The data is collected via a secure electronic portal. The following questions must be answered:

- How is the system operated/used?
- When is the system operated/used?
- How many times per year is the system's energy consumption measured?
- Please compare the energy consumption with the energy consumption of the previous operating year. By what percentage does consumption in the current operating year deviate?
- If consumption has increased by more than 10%, what do you intend to do about it?
- How much refrigerant was added in total in the previous operating year (in kg)?

- Were any major components of the system replaced during the past operating year? If so, which components?

Monitoring is not required for compression refrigeration or compression air conditioning systems with a cooling capacity of 5 kW or less.

Germany has further developed a unique policy instrument based on **"Learning Networks for Energy Efficiency".** This instrument consists of company networks of 10-15 companies that set themselves specific energy efficiency targets in a moderated manner over several years. Details of this approach are described on the website of the network initiative, which now includes nearly 400 networks. The 2022 monitoring report presented the results of 212 networks that had finished their networking activity. The 2,191 companies participating in the 212 evaluated networks reported a total of 9,070 implemented energy efficiency measures. [23]

At the level of measures, lighting measures (27%) were the most frequently implemented. These are followed, at a great distance, by measures in the areas of process technology (15%), compressed air (7%), motors and drives (7%), heating and hot water (7%), and other measures (6%). [23]

2.7 Greece

In Greece, the Antonis Tritsis programme, and specifically its AT03 action, aims at the energy efficiency improvement of water supply and wastewater treatment pumping stations by a series of measures, including replacement of old pumps, adding variable speed drivers, and remote monitoring. [25]

The total budget for the AT03 call for proposals is EUR 150 million.

There have been 139 proposals for funding, exceeding the total budget by about EUR 200 million. The budget of the selected 53 projects will amount to EUR 145 million. [25]

The project is funded by national funds and by the European Investment Bank via the Ministry of the Interior.

The programme is in the implementation phase and not much data regarding its impact is available yet. The managing authority has issued a report stating that the total energy savings from the implemented projects so far are in the order of 28.8 GWh/year.

2.8 Hungary

In Hungary, large energy consuming enterprises are required to install sub-metering devices allowing auditors to audit major energy consuming appliances or units at large energy consuming enterprises. [26]

Since 1 January 2020, large energy consuming enterprises that are mandated to appoint an energy manager. Enterprises that apply for the corporate income tax relief have been mandated by decree to install and operate sub-meters at the following metering points [26]:

- Electronic appliances larger than 100 kW (since 2022: 50 kW) must be measured separately – pumps, compressors, electric motors, etc.
- In factory or building units, production lines with a maximum load than 200 kW (since 2022: 100 kW) must be measured (excluding separately measured appliances).

Exceptions from the obligation to install a sub-meter exist for equipment with less than 2,000 operating hours/year on average in the three years preceding the year in question.

2.9 Italy

The white certificates scheme in Italy includes the installation of electric motors as an eligible action under the "standardised projects", i.e. pre-defined interventions that are recognised for their potential to generate energy savings. These projects simplify the process for participants by providing a set framework for implementation and certification. Each project must adhere to specific criteria outlined

by the National Agency for Energy Services (GSE). Once implemented, projects can apply for white certificates that quantify the energy savings achieved. [27]

The calculation procedure for standardised projects involving motor replacement is defined by the GSE and requires detailed information about both the ex-ante (pre-replacement) and ex-post (post-replacement) motors installed in the production facility. This includes data on their nominal power, efficiency class, number of poles, operating hours, and the presence of a frequency converter.

Additionally, the calculation sheet mandates the inclusion of information about electricity meters, operating hours meters and measured electricity consumption. Using this data, the procedure calculates the annual energy savings expressed in tonnes of oil equivalent (TOE). [28]

Compressed air systems are included in the list of standardised projects as well. A similar calculation procedure is provided by GSE and requires reporting information about the compressors such as nominal power, nominal flow rate, nominal operating pressure, supplied demand, and number of stages. Information about the installed meters for the measurement of electricity consumption, air flow rate and operating pressure, as well as the collected measurements, are required.

The experience with energy audits for industry tracked (under EED Art.8) in December 2019 shows that interventions on motor replacements generated savings of about 88 GWh/year and that planned interventions, identified by means of energy audits, would be associated to a potential saving of approximately 140 GWh, hence showing some potential to be further exploited.

The direct savings are reported in the database as "replacement of electric motors", but other motors could also be subsumed in other categories (e.g., compressors, conveyer belts, etc.), hence actual achievements in motors could be higher. [1]

2.10 Netherlands

The Energy Investment Allowance (EIA) in the Netherlands is a tax incentive designed to encourage businesses to invest in energy-efficient technologies and renewable energy solutions. Under this scheme, eligible companies can deduct 40% of their investment costs from their taxable income, significantly reducing their tax burden. Costs for energy advice are eligible for EIA if the energy advice includes an energy balance of the total plant, an overview of opportunities and quantification of the energy savings, but also organisational and administrative adjustments and other things. [30]

To qualify for the EIA, investments must be made in new equipment listed on the Energy List, which includes technologies that save energy or generate sustainable energy.

Examples of measures listed in the Energy List 2025 that are directly or indirectly relevant for electric motor driven systems include, among others [30]:

Technical provisions for energy saving in existing or new processes: this applies to measures with a payback period of the investment of at least 5 years, but not more than 15 years. In the case of existing processes, historical energy use should serve as a reference. The average energy consumption in the relevant sector for similar technical facilities for comparable new processes should serve as a reference for new processes. The energy savings must demonstrably be the direct result of the use of the operating equipment in which the investment was made. The facilities must achieve energy savings by improving energy efficiency through:

- Using automatic measuring and control equipment
- Using more efficient equipment
- Additional efficiency-enhancing facilities

For ventilation in commercial buildings, a directly driven axial fan with a higher efficiency than defined in the EU Ecodesign regulation is stipulated for storage sheds for agricultural products. Another example is room controllers with a motion sensor to switch the air conditioning systems in existing commercial

buildings depending on automatic presence or absence detection. Another saving measure is the improving the energy performance of existing elevators. [30]

For processes, the following measures are listed [30]:

- Energy efficient refrigeration and/or freezer equipment with at least one frequency-controlled compressor, with condensers with a certain maximum temperature difference between condensing temperature and ambient temperature and weather dependent control of condensing pressure. Both measures result in a lower pressure level and lower electricity consumption of the compressor. For this measure, a maximum amount of EUR per installed kW of refrigeration capacity is defined.
- A similar measure is listed for transcritical CO_2 refrigeration and/or freezing plant, which should also be controlled by a frequency converter.
- Other examples are energy-efficient professional refrigerators or freezer cabinets with a maximum energy efficiency index or energy efficient refrigeration and/or freezer condenser units with a defined minimum seasonal energy performance ratio.
- Other examples are measures to reduce the cooling load: energy efficient milk cooling by recovering heat from the milk, free cooling of server rooms or existing data centres,
- Another example of improvements of cooling systems is the energy-efficient rack cooling by integrated direct expansion systems.
- For ventilation systems, the list includes a system for dehumidification and/or cooling and heating of horticultural greenhouses with a speed-controlled fan. Dehumidification is controlled by a mixture of dry outside air and greenhouse air.
- For the electric motors, highly efficient motors are listed above the levels of the minimum performance standards in the Eco-Design Directive for Motors, but also IE5 motors designed for variable speed, currently not included in this directive.
- For horticultural greenhouses, ventilation in greenhouse farming based on measured crop temperature using an infrared plant temperature camera and control software, and sensors to measure fruit temperature are listed.
- Other measures are speed-controlled vacuum pumps for milking plants, water supply systems for irrigating crops on farmland with pumps driven by frequency converters, and low-pressure systems for irrigating crops. [30]

Under the Dutch policy framework, the **energy saving obligation** requires companies and institutions with an annual energy consumption of 50,000 kWh (50 MWh) of electricity or 25,000 m^3 (approx. 240 MWh) of natural gas (equivalent) to take all energy-saving measures with a payback period of five years or less. [29] The energy measure list (EML) contains measures that are legally established and have a payback period of five years or less for most locations. It consists of three lists that contain a set of measures: one for buildings (e.g. lighting), one for facilities (e.g. compressed air), and one processes. Any other possible measure must be reported according to the official methodology to calculate the payback time. The EML also lists the conditions under which each recognised measure is applicable (current situation, technical or economic precondition, etc.). The following measures involving pumps, fans and compressed air systems are included in the EML [31]:

Pumps:

- Applying frequency controls to pumps
    - Requires a pump of at least 4 kW powered by an IE2 or higher efficiency motor.
    - Applies in case of over 4,100 operating hours per year.
    - Requires space for a frequency controller in the control cabinet.
- Using frequency-controlled circulation pumps
    - Applies to central heating systems without frequency-controlled pumps.

- Ensures optimal flow rate adjustment based on heating demand.
- Requires a heating system allowing variable flow rates.

Fans:

- Replacing indirect-driven volute fans with direct-driven fans
  - Applies to fans with an IE1, IE2, or IE3 efficiency class.
  - Technical condition required: fan power of at least 5.5 kW.
- Replacing IE2 or IE3 fans with IE4 or higher class fans
  - Applicable when fans run more than 1,000 hours per year.
- Installing clock controls for ventilation systems
  - Ensures ventilation only runs when necessary, reducing energy waste.
  - Requires periodic checks to align with actual usage times.

Compressed Air:

- Increasing the compressed air buffer
  - Reduces compressor start/stop cycles and saves energy.
  - Requires a compressor with at least 10 kW power.
- Installing a shut-off valve with a timer
  - Prevents loss of compressed air outside operating hours.
  - Ensures connected machines are suitable for idle operation.
- Using a flow pressure regulator
  - Reduces pressure fluctuations and air leaks.
  - Applies to networks with a central speed-controlled compressor.
- Installing an air duct for compressor intake
  - Allows compressors to draw in cooler external air, improving efficiency.
  - Requires placement near an external wall.
- Using economical compressed air tools
  - Reduces unnecessary air loss and energy waste.
  - Applies to tools used for more than 1,800 hours per year.
- Using electric hand tools instead of pneumatic ones
  - Only use air-powered tools when necessary.
- Using a blower for cleaning instead of compressed air
  - Blower should be placed within 10 meters of the application.
- Replacing compressed air control valve operation with electric actuators
  - Requires an electrical power source within 10 meters.

For cooling systems, many different measures are listed:

- Installation of glass doors for vertical refrigeration units
- Application of night and day cover in semi-vertical refrigeration units
- Placement of day cover on horizontal freezer units
- Insulation of the walls of cold rooms
- Insulation of refrigeration and freezer lines
- Connection of the evaporator fan to the freezer cell door
- Control of evaporator fans based on multiple temperature sensors
- Application of variable speed drive to control the circulation rate in refrigerated storage of plant products
- Separation of air supply to the cooling system from the hot air exiting the cooling system
- Application of condenser pressure control at outside air temperature

For drying, the following measures are included in the list:

- Power control of the ventilation supply to the drying chamber
- Applying a moisture sensor including control in the outlet air of drying processes
- Control of the exhaust air flow rate at drying and muffle furnaces based on the occupancy rate

Other relevant measures include:

- Application of a variable frequency drive to a central dust extraction fan
- Installation of a stop button to prevent unnecessary turning on of the central vacuum system
- Installation of a variable speed drive for the central vacuum system

Additionally, in the case of an annual energy consumption of 10 million kWh (10 GWh) of electricity or 170,000 m^3 of natural gas (equivalent) (approx. 1,6 GWh) or more, an **investigation obligation applies**. This mandates the conducting of a more in-depth analysis, mainly of the manufacturing processes, which includes a description of the installations and processes, a description of implemented energy saving measures, an analysis of the energy usage (description of the monitoring of energy, visualisation of the energy usage), a scan of the technical analysis, an analysis of the electric motor driven systems, and finally an implementation plan. Energy saving measures with a payback period of five years or less need to be put in an implementation plan and must be implemented as quickly as possible. The report must be submitted in the digital portal. [29] The following details about the electric motor driven system must be provided in the investigation template [32]:

- Rated power of the electric motor (in kW)
- Rated voltage (volts) (alternating or direct current)
- Age / year of construction and IE (efficiency class)
- Number of operating hours per year
- Driven device: pump, fan, machine (mixer, press, grinder, etc.), air compressors, process compressor, refrigeration compressor
- Type of control: on/off, soft starter, speed control, other
- Presence of valve control(s) (throttling) and type of use/control position: fixed setting or variable (%-smoothing)
- Load type:
    - constant load (with 0 - 100%); or
    - variable: load variation over time, e.g. <50%, 75% or 100% during operating time.

The investigation template must also include a specification of the possible energy saving measure applicable to the analysed motor driven system, according to the following table [32]:

Table 2: Investigation Template

Component	Relevant characteristics	Possible measures
Motor	**I)** Older than 15 years or with low efficiency (<IE3, as per EU Regulation 2019/1781)	Replacing the motor and/or application at the end of its economic life with high-efficiency models, ensuring proper sizing
Pump (including motor)	**II)** Older than 15 years or with low efficiency (below the minimum efficiency as per EU Regulation 547/2012)	Replacing the pump and/or motor with more efficient versions as required
Fan (including motor)	**III)** Older than 10 years or with low efficiency (below the minimum efficiency as per EU Regulation 327/2011).	Replacing the fan and/or motor with high-efficiency alternatives
Compressor (including motor)	**IV)** Compressor package older than 10 years.	Upgrading or replacing with more modern and efficient compressor systems.
Motor, pump, fan, compressor, machine	**V)** Systems that are not switched off or put into low-power modes during low (process) load or no-load operation and continue to run independently of the process demand.	Correctly regulation of the systems to ensure motors, pumps, fans, compressors, and machines not in use are switched off, and unnecessary bypasses are removed.
Motor, machine	**VI)** Systems not adjusted to changed functional requirements (compared to design), causing underloaded operation (<60% load).	Adapting or replacing the tool with a high-efficiency model, and adequately adjusting power, frequency, flow rate, and control to match demand, with periodic checks
Pump, fan, compressor	**VII)** Systems not adjusted to changed functional requirements (compared to design), resulting in insufficient operation hours near the optimal working range / BEP (Best Efficiency Point).	Optimising operation settings and ensure alignment with BEP.
Motor, pump, fan, compressor, machine	**VIII)** Inefficient components and/or settings, such as throttling control valves, vanes, inefficient transmissions, bypasses, or piping with high flow resistance.	Replacing and/or adjusting one or more components of the drive systems, e.g., removing throttling, implementing speed control, using a high-efficiency transmission, or adopting direct drive with speed control; improving piping design.

The third element is the motor-related company policy statement, i.e. the company must commit to update the data of energy-using electric motor systems on a regular basis and to regularly review the improvement measures. In addition, a maintenance strategy and a strategy for motor replacement must be defined.

2.11 Portugal

In Portugal, the Management System for Intensive Energy Consumers (SGCIE) is the most relevant programme.

The acronym SGCIE stands for "Sistema de Gestão de Consumos Intensivos de Energia", which translates to "Intensive Energy Consumption Management System". It is the transposition of Article 8 of the EED into national law through Decree-Law 68-A/2015. [34]

It applies to intensive energy consuming installations (CIE) with an energy consumption equal to or greater than 500 toe/year. [33]

SGCIE foresees that CIE facilities must periodically conduct energy audits that focus on the conditions of energy use and promote the increase of energy efficiency, including the use of renewable energy sources. It also foresees the preparation and implementation of Energy Consumption Rationalisation Plans (PREn) that contemplate minimum energy efficiency goals. The PREn, when approved, constitutes the Energy Consumption Rationalisation Agreements (ARCE) signed with the Directorate General for Energy and Geology (DGEG). Their compliance is required for operators to receive associated incentives (e.g. financial incentives from the Energy Efficiency Fund) [33]

The PREn is drawn up based on the mandatory energy audit reports and must foresee the implementation, in the first three years, of all identified measures with a return on investment period of less than or equal to five years for installations with energy consumption equal to or greater than 1,000 toe/year, or with a return on investment (ROI) of less than or equal to three years for other installations. [33]

The PREn should also set targets for energy intensity, specific energy consumption and carbon intensity. These targets should be:

- At least a 6% improvement in energy intensity and specific energy consumption, over eight years, for installations with an energy consumption of 1,000 toe/year or more, or a 4% improvement for other installations
- The mandatory registration of the historical carbon intensity values

As of 2024, there were 1,365 companies registered in the SGCIE (764 <1,000 toe/year and 598 > 1,000 toe/year). Over 85% of these companies are in the industrial sector.

From 2008 to 2024, a total of 2,272 PREn action plans were approved. The rationalisation measures proposed in those plans represent a 7% potential for the reduction of energy consumption comparing the reference year to the final date of the plan (8 years). [33]

Of these plans, a total of 1,580 included measures relating to motor optimisation, covering the upgrading of motor efficiency and inclusion of VSDs. The measures proposed in the PREn have an energy saving potential of 29,100 toe/year with a corresponding GHG reduction of 156,200 t CO^2e. These energy savings would result in cost savings of EUR 32,3 million. The suggested measures have an average payback time of 2.6 years.

The potential savings, in toe, relating to motor optimisation measures represent around 13% of the total primary energy savings achieved through the SGCIE scheme.

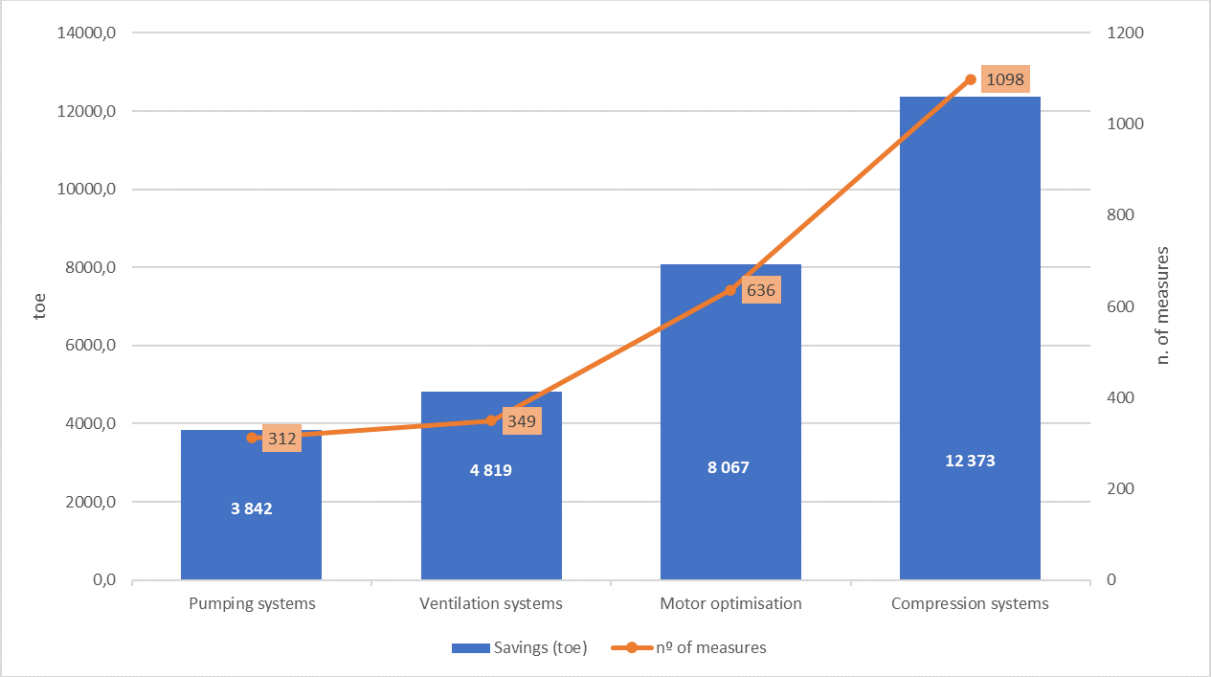

Figure 4: Savings and number of measures in electric motor systems, SGCIE (2006-2024)

Operators of installations covered by an Energy Consumption Rationalisation Agreement (ARCE) benefit from the following stimuli and incentives:

- For facilities with a consumption of less than 1,000 toe/year - Reimbursement of 50% of the cost of compulsory energy audits, up to a limit of EUR 750, recoverable from the execution and progress report (REP) that verifies the execution of at least 50% of the measures set forth in the ARCE.
- Reimbursement of 25% of the investments made in equipment and systems for managing and monitoring energy consumption up to a limit of EUR 10,000.

2.12 Slovakia

The Slovak Sustainable Energy Financing Facility (SlovSEFF) aims to promote energy efficiency and renewable energy projects with private industrial companies, municipalities, small and medium-sized enterprises (SMEs), and large companies. One of the categories for projects' eligibility is industrial energy efficiency. SlovSEFF offers essential technical support from project consultants to assist local bank clients in identifying the most suitable energy efficiency investments. The incentive payment for residential energy efficiency projects is based on the environmental impact that the proposed measures combined can achieve. Under this system, all renewable energy and industrial energy efficiency projects that successfully pass the verification receive a one-time payment as compensation for their carbon reduction efforts. [35, 36]

An energy efficiency sub-projects category includes sub-projects regarding equipment, systems, and processes that enable a reduction of primary energy consumption and/or final consumption of electricity and/or fuels (either of fossil or renewable origin) and/or other forms of energy (which can be ultimately related to the use of electricity and/or fuels) for the provision of services directly related to the industrial sector. [35, 36]

A list of such projects includes, but is not limited to:

- Installation of new chillers
- Installation of variable speed drives on selected electric motors
- Rehabilitation of compressed air systems (e.g., decentralisation and/or resizing of air compressors, replacing of old air compressors with new efficient ones)

- Installation of new heating and ventilation systems

The incentive for industrial energy efficiency projects is calculated as follows:

20 / tCO2e/year x years x annuity factor, with a maximum of 20% and a minimum of 5% of the sub-loan amount.

Individual industrial energy efficiency sub-projects cannot exceed EUR 5 million unless EBRD gives consent (on a case-by-case basis). The minimum IRR for such projects must be 8% (excluding incentive payment).

2.13 Slovenia

In Slovenia, the Eco Fund offers favourable loans with a subsidised interest rate for industry and service sector, intended to finance various investments in environmental protection. [37]

The website reveals a stream of loans for electric motors: installation of energy-efficient electric motors, frequency converters, and systems for the preparation of compressed air.

Financial incentives for efficient electricity consumption includes measures (activities) to improve the following technologies:

- Energy-efficient electric motors
- Frequency regulation of motor revolutions
- Energy-efficient pumps and ventilators
- Energy-efficient systems for preparing compressed air
- Energy-saving lighting

Individual targets of energy efficiency activities are expected to achieve the following effects:

- 4% of electricity savings by replacing electric motors with high-efficiency motors (EU standard IE3) and oversized motors with smaller ones (greater effects in motors with a higher number of operating hours)
- At least 20% of electricity savings through frequency inverters to regulate motor revolutions
- 2% of electricity savings by replacing pumps with energy-saving pumps (with frequency inverters)
- 25% of electricity savings by replacing ventilators with energy-saving ventilators (with frequency inverters)
- Electricity consumption reduced by at least 10% by eliminating leaks, regulating the distribution of compressed air and optimising the regulation, and around 25% by replacing compressors

2.14 Sweden

In Sweden, the Programme for Improving Energy Efficiency in Energy Intensive Industries (Swedish abbreviation: PFE) was implemented in 2004 through a new law that regulated long-term voluntary agreements between the state and energy-intensive companies in the form of a programme. The law set a few qualitative requirements for companies to achieve within the five-year programme period. In exchange, companies received a reduced electricity tax of 0.005 SEK/kWh. [38]

The companies committed to:

- Implement and certify an energy management system
- Carry out a comprehensive energy audit
- Implement electricity efficiency measures to achieve their energy efficiency targets/commitments
- Introduce energy considerations in purchasing and design processes

Measures that can be related to motor drives touch many different areas of action and account for about 25% of the efficiency improvements, of which 11% are in pump systems and only 2% are related to motor replacement.

The reported electricity efficiency improvement of 3 TWh per year corresponds to a 10% reduction in the total electricity consumption of the companies. Estimates made by the companies and assessments in academic reports show that about one third of the efficiency gains probably occurred without the PFE. This leads to a net result of 2 TWh per year. Of these savings, around 25% are attributable to measures in motor driven systems (fans, compressors, pumps, refrigeration systems, etc.), corresponding to around 500 GWh per year. [38]

2.15 International programmes

The European Motor Challenge Programme

The European Motor Challenge Programme (MCP) was launched by the European Commission in 2003. The program aimed to encourage European companies to implement measures to improve the energy efficiency of their motor-driven systems.

Key elements of the MCP:

- **Voluntary commitment mechanism:** Companies can participate as partners and commit to taking specific measures to reduce energy consumption.
- **Action plans:** Partner companies create and implement action plans that include measures in various areas such as compressed air, fans, and pumps. The 93 MCP Partners came from different industrial sectors with the focus on production and processing originating from 16 countries in the European Union. For each of the different systems (pumps, fans, compressed air, chillers, motors) short documents were prepared, which should help companies or their advisors to formulate these action plans.
- **Technical support:** The Commission and national energy agencies offer support, advice, and technical assistance in formulating and implementing the action plans.
- **Public recognition:** Partner companies receive public recognition for their contribution to achieving the European Union's energy and environmental goals.
- **Energy savings:** The program has led to significant energy savings, with the largest savings achieved in the area of electric drives. [39]

Compressed Air Challenge

The Compressed Air Challenge (CAC) is a programme dedicated to promoting energy and operational efficiency in industrial compressed air systems. Its main goal is to help end users adopt efficient practices and technologies, leading to significant energy and cost savings. The challenge involves several key elements:

- **Training and education:** CAC offers various training programmes, including online and in-person courses, to educate industry professionals and/or employees on best practices for optimising compressed air systems.
- **Best practices manual:** This comprehensive guide provides detailed information on improving compressed air system performance, including practical tips and case studies.
- **Collaborative efforts:** The challenge brings together stakeholders such as equipment manufacturers, utilities, government agencies, and end users to share knowledge and resources.
- **Performance evaluation:** CAC provides tools and methodologies for evaluating the performance of compressed air systems, helping organisations identify areas for improvement.
- **Resource library:** An extensive online library offers access to articles, videos, fact sheets, and other resources to support continuous learning and improvement. [40]

SwissEnergy – Information and tools on motor drive systems

On the SwisssEnergy website (energieschweiz.ch/antriebssysteme), you will find resources and tools for optimising various motor-driven systems, including [41]:

- Pump systems: guides and tools for improving the energy efficiency of pumps, including maintenance checklists and optimisation measures.

- Ventilation systems: information on optimising ventilation systems to reduce energy consumption and improve air quality.
- Cooling systems: resources for enhancing the efficiency of cooling systems (e.g. annual cooling checklist), including free cooling solutions and cooling and energy demand calculator. The cooling tool allows businesses to estimate the energy demand and greenhouse gas emissions of their cooling systems. It also helps compare the efficiency and economic viability of different system variants. [42, 43]
- Compressed air systems: guides on detecting and repairing leaks, improving system controls, and upgrading components to enhance efficiency, checklists for compressed air service and analysis. The information also includes instruction videos for the most relevant saving options and a guide for a four-steps optimisation procedure. [44]
- Energy efficiency guide: information on improving the energy efficiency of electric motors and drives, including practical measures and checklists.

This information includes among others more than 32 fact sheets on topics relevant for the optimisation of drive systems. [45]

Furthermore, Topmotors (financed by SwissEnergy) published the following tools for the so-called Motor-Systems-Check [46]:

- Topmotors Tool SOTEA for generating a rough estimate after the first overview based on minimal data from the operation under review and shows the proportion of motors in the total energy consumption
- An Excel-File for generating an intelligent motor list (ILI+) in companies
- The Standard Test Report (STR) helps to evaluate the data collected from the measurements and to describe the current actual state.

Other offers include:

- Expert consultations to guide businesses through the optimisation process and connect them with specialised professionals
- Information on potential funding and subsidies available for energy efficiency projects
- Educational resources such as webinars and workshops to help businesses learn more about energy-efficient solutions

ProKilowatt: Promotion of electricity efficiency measures in companies

Within this programme of the Swiss Federal Office of Energy, organised as a competitive tender programme, bidders can apply for projects or programmes that are a combination of several projects led by a third party. As a rule, all electricity-saving measures that are not economically viable and with investment costs per end-user of less than CHF 300,000 are eligible for funding under the subsidy regulations. For higher costs, companies can submit a project application directly to ProKilowatt. Criteria for funding is the cost effectiveness, defined as the amount of subsidy in CHF divided per the amount of energy saved over the equipment's lifetime in kWh. [47]

The whole programme has been running since 2010 with the goal to save electric energy in households, industry, and services with an annual budget of EUR 50 million per year. A total of 956 projects and programmes have been financed until 2023, and a total of 1,020 GWh/a (14.5 TWh electricity saved over the equipment's lifetime) were saved. The average cost effectiveness was 3 cent/kWh saved. Motor systems delivered the biggest share of savings with 205 GWh/a, followed by lighting systems. As for applications, especially cooling compressors, circulators, mechanical processes, fans, and air compressors were successful and delivered the highest savings. [50, 51]

Programme requirements were a maximum duration of three years, a maximum budget of EUR 3 million, and a maximum budget share of 10% for programme management, training, communication, and monitoring. The support for analysis cannot be more than 10% of the subsidy.

The following is an overview of selected funding programmes by ProKilowatt relevant for motor driven systems [47]:

- Replacement and optimisation of refrigeration and air conditioning systems in SMEs and industry in Switzerland: ProFrio
- Programme for energy-saving measures in server rooms and data centres: PUEDA+
- Replacement and optimisation of electrical drives: SPEED
- Replacement and optimisation of compressed air systems: ProEDA
- Replacement and optimisation of ventilation systems: ProELA
- Replacement of inefficient pumps in non-residential buildings: PUMPIND

All programmes differ slightly in terms of financing and other factors. For example, the Speed III programme, which focuses on the optimisation of electric drives, comprises the following elements [48]:

- Financial support for renewals/investments to optimise electric drives in industry
- Promotion of measures for motors, pumps, fans, chillers, air compressors and other electric drives
- Expert support to identify the best potential savings, carry out detailed analyses (where relevant and desired), and develop and quantify optimal solutions.

The offer includes:

- Free processing of the dossier and advice
- Detailed analyses (50% support), if desired and appropriate
- Funding of up to 30% of the investment

Subsidised systems must have the following parameters:

- Pumps (> 5 kW and > 2,500 h/a)
- Fans (> 5 kW and > 2,500 h/a)
- Ventilation (> 10,000 m^3/h and > 2,500 h/a)
- Compressed air (>15 kW and 50,000 kWhel/a)
- Refrigeration system (>50 kWh cooling or 100,000 kWhel/a
- Motors (> 10 kW and > 3,500 h/a)
- Other drives (> 10 kW and > 3,500 h/a)

General terms and conditions comprise:

- Application for funding must be made before ordering.
- Funding is available for replacement systems or retrofits.
- The payback of measures must be more than four years.
- Measures included in a binding target agreement or in an energy audit are not eligible for funding.

As another example, some details of a programme focusing on replacement and optimisation of compressed air systems, ProEDA, are listed here [49]:

- A very rough saving calculation tool for a first self-assessment with a limited number of input parameters is available online: parameters include the name of the producer, type, age, and power of the compressor. Further information must be provided if the compressor is switched off at night: the number of shifts in the company, the running hours, and the minimum and maximum pressure level of the system. [49]
- There are two funding options, depending on the power of the compressor system:
    - For compressed air systems from 5 kW to 50 kW and a total energy requirement of less than 25,000 kWh/a, applicants receive subsidies for those actions that lead to the highest energy efficiency improvements without the need of any prior analysis. This option is suitable for smaller systems whose low annual consumption does not justify the cost of an analysis.
    - For compressed air systems with more than 50 kW or with a total energy requirement of more than 25,000 kWh/year, an analysis of a potential renewal and optimisation of the

system is recommended. This option incorporates a higher savings potential and higher funding budgets. realise more savings and receive more funding.

Evaluation of the ProKilowatt Programme and its success criteria

The motor system programmes within the ProKilowatt programme were subject of a detailed evaluation in 2023. More in particular, some of the programme requirements were considered as barriers for achieving maximum savings. These requirements included the maximum duration of three years, the maximum budget of EUR 3 million, the limitation of the budget support for analysis to 10% of the subsidy, and the maximum budget share for programme management, training, communication and monitoring of 10 %. As the programmes tried to limit each budget post, the number of supported analyses was declining. [51]

System optimisation was only rarely executed, the training of consultants was missing, and the programme communication was limited. Since there was a wide variety of programmes, it was difficult to keep an overview. The competitive tender came close to reaping the savings potential available within the programme, which was more a matter of "low-hanging fruits" than of going deep into system optimisation. [51]

For the evaluation of the ProKilowatt programme in Switzerland, the most critical factors for programme success were identified [51]:

Contact via established channels is an important factor, and it must be continuous and based on trust. If consultants are involved, a sufficient incentive for consultants to engage with the industrial end users during the analysis is needed, and the implementation of the suggested measures should be supported. Different channels for programmes to reach their participants should be considered. These comprise technical partners, such as installers, manufacturers, vendors, and service companies. The build-up of such partnerships takes time. For each country, different channels can be used, but each of them have specific limitations. In Switzerland, a channel for reaching the participants was found in the existing network of consultants within the voluntary target agreement scheme. The limitation due to different levels of the consultants' know-how concerning electric motor systems resulted in a different prioritisation of motor systems within a general audit. Depending on the programme manager, another channel could be available in the network of industrial clients, but the possibility of expanding such a network is limited.

The second factor is the programme awareness. Programmes that aim to be increasingly known among the target groups are in greater demand but need a longer time horizon to reach the target group.It should be as simple as possible for participants to join and implement the programme, from the application to the monitoring of the results. The administrative barrier should be kept low, and a simple and easy to understand subsidy scheme is to be preferred. A certain percentage of the investment cost can be easily determined and communicated. The subsidy should be between 20 and 30% of the investment costs.

- Consultants should have sufficient expertise in the field of motor driven systems and the ability to carry out the analysis. Qualification and accreditation programme is needed to assure this.
- As a goal for optimised programmes, the programmes should not focus merely in "low-hanging fruit", but also on system optimisation (not only one component). They should also focus on the largest saving potential (meaning old, big, oversized machines).

Four building blocks were identified that could potentially improve the programme, which could be implemented individually or in combination [51]:

1. A subsidy programme for end users with an energy demand of more than 500 MWh/a, targeting motor systems older than 15 years with an energy consumption of 10 MWh/a or more. Typical measures include more efficient components, motor systems optimised for their process requirements, the elimination of standby consumption, and the use of variable speed drives.

2. A utility programme could offer subsidies for motor system optimisation. This could include progressive tariff reduction based on achieved savings, free monitoring instruments, such as smart sensors, or the build-up of technical competence in utilities themselves.
3. An innovation programme (promoting innovation and technical progress through mass production and upscaling) consisting of a public procurement programme for equipment producers, should be implemented. The idea is to decrease costs for innovative pump, fan, and compressor systems through economies of scale. The public authority responsible for launching this programme would also be responsible for launching the tendering process for the design and manufacturing of these systems.
4. Accompanying measures which could include technical and administrative training, the accreditation of trained persons, central points of contact, information campaigns, and tools for preliminary analysis and programme administration.

2.16 Key elements of, and recommendations for, policy programmes for motor driven units and systems

In this sub-chapter, some important observations and recommendations derived from the analysis of the policy programmes listed above are summarised. Voluntary agreement programmes are not mentioned, as they were comprehensively analysed in the EU-MORE Deliverable 4.3 Policy Impact Analysis [65].

Key elements of awareness raising and training programmes

An analysis of awareness raising and training programmes, including their success factors, is provided in EU-MORE D 4.3 – Policy Impact Analysis [65]. For all kind of support schemes, it is recommended to incorporate a campaign with at least some of the elements mentioned below [52]:

- Awareness-raising material
- Best-practice case studies
- Energy efficiency awards
- Technical guides and training
- Tools to optimise motor systems and to assess life-cycle costing.

Here we will give examples from Switzerland and Austria. Both countries have initiated focussed programmes as a part of larger, national energy efficiency initiatives. They provide detailed material on various types of motor driven systems, which were developed in close collaboration with key stakeholders. As mentioned above, they include:

- 2-page fact sheets and videos addressing company managers
- Tools for a quick estimation of the saving potential that can be used at the start-up phase of a project
- Purchasing recommendations and calculation tools for choosing the right equipment
- General information material providing insight in the various aspects of motor driven system efficiency
- Audit guides for auditors and energy managers to select and evaluate the systems with the highest potential and identify the most appropriate saving opportunities
- Planning guides to implement new systems, and posters for on-site use to motivate employees
- Trainings for energy auditors, energy managers, and energy utility employees
- A system for developing and publishing use cases, and awards for implemented projects

Energy audit programme

According to EN 16247-1, an energy audit is a systematic inspection and analysis of energy use and energy consumption of a building, system or organisation with the objective to identify energy flows and the potential of energy efficiency improvements and to report on them. [4]
In principle, all relevant energy consumption areas must be evaluated, including electric motor systems. As it is not possible to check all systems, usually the auditor and company concentrate on the biggest motors, e.g. the motors included in air compressors. It is recommended to follow a two-step approach: first make a list of all relevant motors including their purpose (e.g. pumps, fans, ...) , and then proceed

with the motor systems with the highest saving potential. But even then, it is sometimes not possible to analyse all the selected systems in detail within the budget and time available for the energy audit. Sometimes, e.g. in sawmills, even bigger motors are not included in the energy audit.
Therefore, additional programmes or subsidies are needed to incentivise the optimisation of these systems, either through separate programmes for detailed analysis or by including motor systems in an investment subsidy programme. Another possibility could be a mandatory efficiency check on a regular basis, though this is currently not implemented (only within the German chiller programme, in combination with a subsidy for a new chiller).

The following elements are to be considered for energy audit programmes:

- Stipulation and enforcement of energy audit requirements, for all companies or only for big companies, and subsidies for energy audits at smaller companies.
- Definition of the intervals at which energy audits should be conducted. With the four-year interval currently defined in the European Energy Efficiency Directive, the data collection effort during each subsequent audit can be substantial again. A shorter time frame would be recommended to reduce data collection efforts.
- Within the auditing methodology, there should be a requirement to draw up an inventory list of all (or at least the biggest) electric motors. Motor systems could be explicitly identified as a primary target for energy audits.
- A rough analysis of compressed air, chillers, fans, pumps, other motors like mills, saws, and conveyor belts should be explicitly mentioned to be in the scope of such audits and in the evaluation of energy saving measures.
- For the saving measures, an indication of which measures should be checked for these systems should be included, as in the energy audit obligation in the Netherlands. These measures can include, for example, the replacement of a pump or a fan with certain age or with low efficiency, the control of certain systems, etc.
- An inventory list, including the energy consumption of these systems, should be mandatory in the reporting obligations.
- Energy audits should include an action plan, with incentives to implement the actions, e.g. a mandatory implementation of energy saving measures with a short payback-time (e.g. below three or four years), and/or a mandatory publication of the action plan.
- A detailed analysis of certain systems, to be included in the action plan.
- For the qualification of energy auditors, minimum levels of education, training and professional experience should be defined and checked. This qualification should include basic trainings on the biggest motor driven systems in companies.
- For detailed energy audits of motor driven systems, guidelines and data collection sheets should be published, including the energy saving calculation methods for the major energy saving opportunities within these systems.
- Information and training material for the data collection and optimisation of electric motor driven systems should be provided, including information on the costs (e.g. for motors and frequency converters, chillers, compressed air, fans, and pumps).
- Training of key personnel (energy managers, energy technicians, energy auditors) is crucial for the best possible optimisation of existing motor driven systems. Trainings should include, among other topics, audit guidelines and specific energy efficiency topics related to the optimisation of motor systems and to the identification of opportunities such as the implementation of a VSD.
- Support for detailed analysis should be provided. One way is to include it in the investment subsidy, by listing it as an eligible investment cost.
- Mechanisms for monitoring the progress of participants and evaluating the success of the programme are crucial to gain long-term support for the audit programmes and requirements and to stimulate the participants to develop further.

Tax programmes

Tax programmes have already been described in EU-MORE D 4.3 – Policy Impact Analysis [65]. The most important points are summarised here, with the addition of some information from the analysis of programmes for motor driven systems mentioned in this report.

The concept consists of tax rebates or other tax incentives for companies that optimise their motor driven systems. The aim is to reduce the financial burden of replacing motors or motor driven systems (such as pumps, fans, or compressors) and to encourage the use of energy-efficient technologies or the installation of controls that optimise the system (e.g. variable speed drives). This policy measure aims, among other things, to tackle organisational barriers, including resistance to change. Such policy measures are usually part of voluntary agreements in the industrial sector and could boost investments which are economically favourable. Therefore, they should preferably support investments with a payback time of less than three to four years.

A tax rebate is essentially a refund of taxes that have already been paid or a return of a part of the taxes paid, based on specific criteria or circumstances. Other tax incentives include tax credits, such as permitting the full or incremental costs of energy efficient motor systems to be deducted from taxable corporate profits, and VAT rebates. These incentives have the same impact as direct grants, but offer the advantage of simplified application, as they utilise the existing tax administration system. However, like grants, they still impose a burden on public budgets. [54]

As with any financial incentive, the exact amounts that are granted should be selected carefully so as to facilitate investments while preventing negative side-effects such as rebound effects and free riders. Tax incentives may not always be a strong incentive for businesses, as these non-transferable incentives only work if a profit is made. [54]

Usually, a minimum amount (e.g. EUR 2,500) and a maximum amount are defined. In the case of the Energy Investment Allowance in the Netherlands, companies can deduct 40% of the investment costs from the taxable profit. This deduction comes on top of the usual depreciation and applies for investments in technologies that are included in the annually revised "Energy List" [30]. It is recommended to include the costs for energy consulting or energy advice. These costs are applicable if the advice includes an energy balance of the total plant, an overview of opportunities and quantification of the energy savings, but also organisational and administrative adjustments.

As mentioned in the evaluation of this programme [53], such a list can be a driver for accelerated market introduction of energy-efficient techniques by introducing new technologies or increasing the mandatory energy efficiency. For example, highly efficient motors, fans, pumps, or chillers with higher efficiencies than those defined in the Minimum Performance Standards within the EcoDesign-Directive could be supported by such a measure. In the Netherlands, this is the case for several specific systems. Measures at the system level can also be included. For cooling systems, examples of measures at system level include compressor control with a frequency-converter, weather-dependent control of the condensing pressure, highly efficient condensers, or measures that reduce the cooling load. Another example of a measure at system level is crop temperature or moisture measurement for the control of ventilation systems.

In the Netherlands, the effective deduction rate is considered to be high. A lower rate could lead to fewer free riders (in the financial sense, i.e. participants that would buy the product anyway), while largely maintaining the attractiveness of the scheme.

Energy Saving Obligation

Another interesting instrument is the energy saving obligation for companies (not energy utilities), also implemented in the Netherlands.

Under the Dutch policy framework, the energy saving obligation requires companies and institutions with an annual energy consumption of 50,000 kWh (50 MWh) of electricity or 25,000 m^3 (approx. 240 MWh) of natural gas (equivalent) to implement all energy-saving measures with a payback period of five years or less. The Energy Measure List in the Netherlands [31] contains measures that are legally established and that have a payback period of five years or less for most locations. It consists of three lists with a set of measures: one for buildings (e.g. lighting), one for facilities (e.g. compressed air), and one for processes. Any other possible measure must be reported according to the official methodology to calculate the payback time. Within this list, many measures are included that do not need a lot of investment, e.g. the installation of a stop button, and also many different measures on the demand side that do not need optimisation of the motor drive unit, but lead to less energy consumption of the electric motor, e.g. insulating of the walls of the cold room to reduce the energy consumption of the cooling compressor. The energy saving measures must be reported online, and the competent authority (the municipality in which the company is located) is responsible for the monitoring and enforcement.

Subsidy programme for optimisation of motor driven systems

As described in the EU-MORE final brochure [55], a significant proportion of the identified policy measures address industrial energy efficiency in general rather than motors in particular. Such "technology-neutral" policies can steer decision-makers to the most profitable measures, but their impact risks being limited to the "low-hanging-fruit" and depend on industrial decision-makers having the insight to make judgements based on the whole picture. These drawbacks, combined with the fact that motors represent 70% of industrial electricity demand, could justify developing motor-specific initiatives. [55]

It is therefore suggested to develop programmes that are specifically dedicated to either a technology (e.g. chillers) or a specific target group, and that run for a period of two to three years. The focus can extend beyond replacement to include other optimisation measures, such as improved controls or leak detection. For general programmes, the target group may be kept rather broad, e.g. including service and industrial companies.

Establishing contact with the target group is essential for the successful implementation of a programme. Cooperation with industry organisations and installers or service companies, for example, ought to be planned from the outset to enhance awareness and foster commitment to the objectives. It is also crucial to establish a coordination with existing public programmes, e.g. other national or regional subsidy programmes or financial incentives, but also awareness raising campaigns and voluntary agreements. This should be considered from the beginning of the planning process.

If, for example, a dedicated audit obligation or subsidy for consultancy services is available, it should be checked whether those programmes already include the possibility to support part of the necessary evaluation, such as the initiation of a motor inventory at company level, or a first rough analysis of motor driven systems in the company.

An integrative approach with awareness-raising programmes and training initiatives for energy managers, consultants and designers, is also very important.

Other general issues were already mentioned in EU-MORE D 4.3 – Policy Impact Analysis [65]. The most important points are summarised here, adding some information from the analysis of the programmes for motor driven systems mentioned earlier in this report:

- Eligibility assessment: identifying businesses or projects that qualify for subsidies based on predefined criteria (e.g. size and sector of companies, definition of kind of product, characteristics such as size and efficiency requirements, etc.)
- Application process: interested parties submit applications detailing their intended upgrades and expected benefits. A proof of analysis or efficiency tests can be mandatory. However, the

administration process should be as simple as possible, with little documentation and quick decisions on the funding.
- Funding allocation: upon approval, funds are disbursed to support the purchase and installation of new energy-efficient motor driven systems. Usually, there is a minimum amount of investment costs, e.g. EUR 2,000 to 10,000, a maximum funding amount, e.g. EUR 150,000 to 300,000, and sometimes a limitation of e.g. EUR 750 EUR per tonne of CO_2 saved.

The funding can depend on the installed power (a correction factor can be integrated here to incentivise motor downsizing). The funding can also depend on the amount of savings, (e.g. 1% per s% of savings, and increase with higher savings, e.g. 1.5% above 30% with a cap at the maximum subsidy rate of 40%). There can be bonuses, e.g. for companies with certified energy management systems (e.g. EMAS or ISO 50001), or for the installation of thermal storage, waste-heat utilisation, or free-cooling operation.

Analyses should be considered as part of the investment costs and can be differentiated between rough and detailed analyses, depending on the power of the equipment or the potential savings.

Hammer et al. describes these measures as follows (translated by author):
"The engineering includes the necessary preliminary clarifications (rough and detailed analysis) as well as support for the actual implementation of the optimisation measures:

- Inventory, analysis of the current status, measurements (frequency converter, motor/gearbox/transmission/pump, etc.), observations (temperature, vibration, etc.), surveys (operating data), fault analysis, process monitoring, operational ideas for process modification, expansion, etc.
- Optimisation ideas, target state: energy consumption calculation, simulation start, load change, batch cycle, costs, operating expenditure, cost/benefit analysis, system selection, report, explanation to management, budget, funding application, time programming, priorities, etc.
- Implementation: specification, tender, comparison of offers, application for award of contract, contract negotiations, schedule.
- Construction management, acceptance tests, control, measurements.
- Evaluation of effective measured condition vs. actual condition, cost settlement, subsidy settlement, final report.
- Monitoring over 3 years, report." [51, page 81, 82]

In the proof-of-use, the applicants prove that they have carried out the measures as approved, met the deadlines, and fulfilled the conditions. Among other elements, it must include technical parameters of the installed refrigeration or air conditioning system and its components. Required documents can be [22]:
- Completely filled-out electronic proof-of-use form
- Flow chart of the system installed
- Proof of efficiency for the system installed (e.g. for systems with an electrical power consumption of 20 kW or more)
- Supply and service contract
- Maintenance contract or proof of in-house maintenance
- Invoices for the eligible expenses
- Notice of installation of an electric energy meter and/or other meter with details of the commissioning date (e.g. for systems with an electric power above 5 kW)
- For systems that have been retrofitted for efficiency, technical parameters must be confirmed by the respective expert company (= refrigeration system installer).

For monitoring and reporting, recipients are required to report on their energy savings and other types of post-implementation impact to ensure accountability and monitoring of the measure's effectiveness.

For larger installations, e.g. above 5 kW, the installation of a power meter can be mandatory. For installations above 20 kW, proof of efficiency, i.e. measurement of heat, cooling or flow, can also be subscribed. Reporting on savings or efficiency over a period of three years is a good incentive for companies to monitor their industrial plant on a regular basis for a longer period.

3. EU-MORE Policy Recommendations

This chapter analyses the policy recommendations already developed in work package 2 of the EU-MORE project (published in EU-MORE D 2.3 – Co-Created Policy Recommendations for Electric Motor Renovation [64]) and the possibility to replicate them to policy programmes for other elements of motor driven systems.

3.1 Initiate a data collection programme

This is based on the EU-MORE policy recommendation: "Collect baseline data, e.g. through energy audits, on motor stock, including nameplate data such as power rating and energy efficiency, as well as age and load characteristics (variability and average value). This would enable a more efficient design and monitoring of policy measures and could assist companies in optimising their investment decisions related to motor replacement and the optimization of motor systems. Assessments regarding motor systems made by energy audits should be reported to the managing authority." [64]

Remark: this policy recommendation is also relevant for other main components of motor driven systems. For example, pumps and fans, but also chillers and compressed air units, are sometimes running longer than expected (in some cases for more than 20 years). As a result, relevant data on the component and its running condition are often outdated. For motor driven systems, this recommendation could be re-formulated as follows to include other parts of the system:

"Collect baseline data, e.g. through energy audits, on motor stock and the driven application (e.g. pump, fan, compressor, conveyor), including nameplate data such as power rating (rated flow and pressure if applicable) and energy efficiency, as well as age and load characteristics (variability and average value). This will enable a more efficient design and monitoring of policy measures. Moreover, such a programme can assist companies with optimising their investment decisions related to motor replacement and the optimisation of motor systems. Assessments regarding motor systems made by energy audits should be reported to the managing authority."

3.2 Initiate a subsidy scheme for motor system investments and a scrappage scheme for old motors

This is based on the EU-MORE policy recommendation: "Provide adequate subsidies to support motor system investments identified by energy audits that have a high energy saving potential but are not economically attractive. Among other, update the list of eligible activities to include investments with high energy saving potential like the installation of VSDs. Select the subsidy rate carefully to deter free riders. The subsidies can also be connected to the scrappage of an old, inefficient motor, confirmed by a certificate." [64]

Remark: several programmes already include improvements in pumping, ventilation or compressed air systems, in addition to motor optimisation measures. In some cases, separate programmes for chillers are available, but with a focus on replacing refrigerants that have a high impact on global warming. The main part of this policy recommendation is therefore still valid. For such specific programmes, e.g. directed to chillers, it can be a good idea to describe some elements in more detail, such as which technologies and equipment exactly are subsidised, or which measures are compulsory and which are optional. The subsidy should include expenses that are needed for making a more detailed analysis of the existing system and for engineering of the new one, including stationary monitoring equipment. In one case, an efficiency calculator is even provided by the programme and must be used for certain investments. Furthermore, stipulations for the proof of use (e.g. diagrams, acceptance tests, efficiency

calculation, invoices) and an annual monitoring for three years (e.g. energy consumption measurement) should be part of the programme.

3.3 Initiate a tax incentives scheme combined with voluntary agreements for "low-hanging fruit"

This is based on the EU-MORE policy recommendation: "Provide adequate tax incentives combined with Voluntary Agreements to enable the implementation of investments identified by energy audits as having a high energy saving potential and being economically attractive (i.e. payback <4 years and /or sufficiently high IRR) but which are still not implemented due to organizational barriers." [64]

Remark: the main measures for optimisation and replacement of all types of motor-driven systems should be part of the catalogue of applicable measures for the tax incentive scheme, as is the case in the Netherlands. These measures may cover new components (fans, pumps, compressors), the adoption of new control and monitoring equipment, and should also encompass engineering work.

For voluntary schemes, it is important to incorporate training and awareness-raising measures aimed at auditors, consultants, and companies that provide information on savings and technologies in motor driven systems. Additionally, the scheme could establish minimum standards for new equipment exceeding those defined in the associated Ecodesign-Directive and require a mandatory inventory list for all types of motor driven systems.

3.4 Update the established Energy Efficiency Obligation Scheme to indirectly finance energy audits

This is based on the EU-MORE Policy recommendation: "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." [64]

Remark: this recommendation already includes the auditing of motor driven systems. When implementing the programme, clear stipulations for the auditing of motor driven systems should be given. Furthermore, training activities for the auditors and energy managers of companies should be included.

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

This is based on the EU-MORE Policy recommendation: "SMEs frequently lack insight in the potential benefits of motor investments, as well as the necessary resources to undertake high quality energy audits or implement an Energy Management System (EnMS). Free-of-charge energy audits and capacity-building activities could fill this gap." [64]

Remark: for motor driven systems, it is important that the auditors are trained in the analysis of those systems. The audit should at least include a motor inventory and should assess the measures for motor driven systems with the biggest saving potential.

3.6 Initiate an Information and Capacity-building Programme

This is based on the EU-MORE Policy recommendation: "Initiate an information campaign targeting all stakeholders involved in motor investment decisions in industry and the tertiary sector. Develop and run training programmes for energy auditors to keep them up to date with technological innovations and to ensure the quality of energy audits." [64]

Remark: for optimising electric motors, knowledge on efficiency classes and demand characteristics such as speed, torque, and starting torque, do often suffice. For optimising other systems, a broader knowledge on the different components and their physics is essential. For air compressors, for example, knowledge on the required pressure levels is needed, while optimising chillers requires knowledge on the different pressures and temperatures within the cooling circle. This makes it useful to develop separate training programmes (or at least separate courses) for each of these systems .

4. Saving Calculation

One of the targets of the EU-MORE project was the calculation of the saving potential of replacing elements other than the motor itself of motor driven systems, such as pumps, fans, and compressors, on a general basis.

For motors alone, the average 4% efficiency gain for the full replacement of an old and inefficient motor (IE2 or below), which is the average difference between IE1 and IE3 class motors, translates into 25 TWh/year of savings. The savings would be even larger if the replacement were made with the best available technology motors (IE4 for fixed speed applications (already mandatory in the EU in the 75-200 kW range) or IE5; for variable speed applications (SynRM IE5 motors cost about the same as IE3 induction motors and provide larger savings).

Pumps, fans, and compressors are essential components in various industrial, commercial, and residential applications, accounting for a significant share of electricity consumption in the EU. These devices are used extensively in sectors such as manufacturing, refrigeration, heating, ventilation, and air conditioning (HVAC), as well as water and wastewater treatment.

Collectively, they account for approximately 50% of the total industrial electricity consumption in the EU. They also account for a significant share of the consumption in the services sector, with over 30% of the total electricity consumption in that sector.

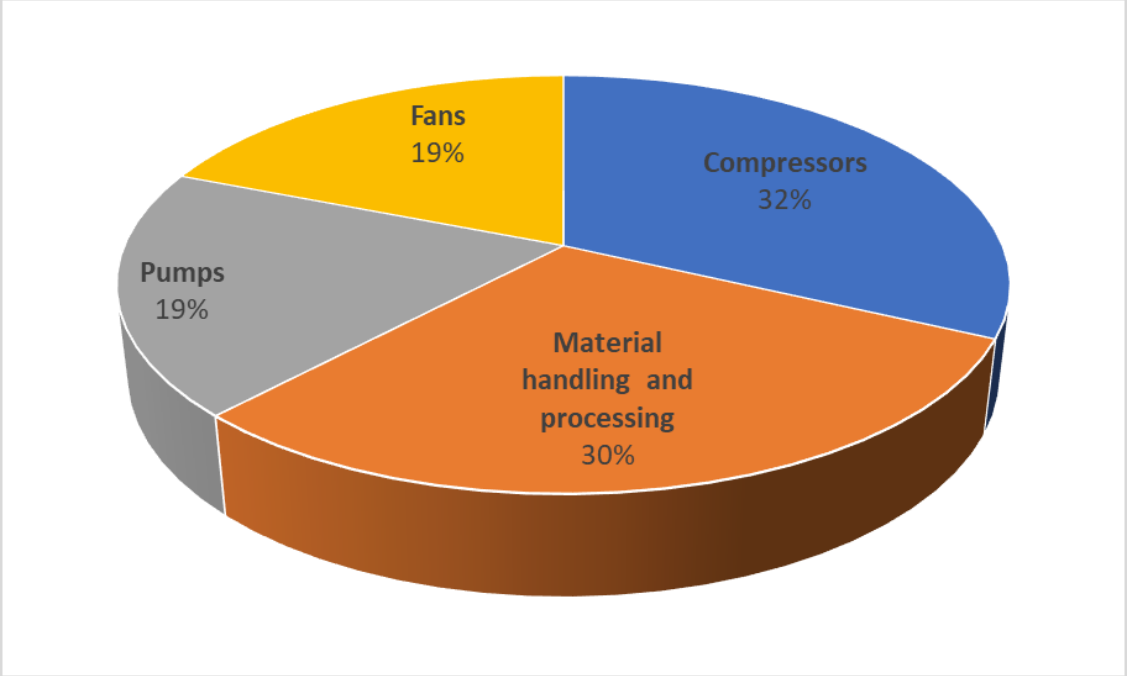

Figure 5: Estimated share of electric motor electricity demand by end-use application [56]

- Pumps: Pumps are used in water supply, heating, cooling, and industrial processes. They account for 19% of the total industrial electricity use.
- Fans: Fans are widely used in HVAC systems, ventilation, and industrial processes. They represent about 19% of the industrial electricity demand.
- Compressors: Compressors, primarily used in air compression and refrigeration, are among the most energy-intensive components, contributing to around 30% of the industrial electricity consumption.

This means that pumps, fans, and compressors were responsible for around 412 TWh of electricity consumption in the industrial sector alone, in 2023 [57].

The recognition of the extent of the electricity consumption of these products, and their potential for savings, has led to the introduction of regulation for the minimum energy efficiency requirements for water pumps (Commission Regulation (EU) 547/2012) and fans (Commission Regulation (EU) 2024/1834). Refrigeration compressors are covered by the regulation on professional refrigeration equipment (Commission Regulation (EU) 2015/1095). Air compressors, although the subject of a preparatory study, are not covered by regulations under the Ecodesign framework.

Estimates of the annual electricity consumption of these products in the EU vary, likely due to differences in the classification and scope of products included in the analysis. The following table summarises recent electricity consumption estimates carried out under the scope of the Ecodesign-Directive studies.

Table 3: Estimates of the electricity consumption, 2020 [TWh/y] (figures in brackets are source references)

Product	Minimum electricity consumption [TWh/y]	Maximum electricity consumption [TWh/y]
Water pump	180 [58]	208,4 [59]
Fan	229 [60]	281 [58]
Refrigeration compressor	85 [61]	118 [58]
Air compressor	55 [62]	55 [60]

Lifetimes

Assumptions for the average lifetime of the products under consideration, used to calculate their lifetime environmental impact, are presented in Table 4.

Table 4: Assumptions of average product lifetimes (figures in brackets are source references)

Product	Lifetime [years]
Water pump [59]	10
Industrial fan [63]	15
Air compressor (package) [62]	10–14
Refrigeration compressor [61]	8–15

As with motors, anecdotal evidence seems to indicate that the average lifetime of pumps, fans, and compressors can largely exceed these assumed lifetimes, particularly in the case of industrial use.

Potential electricity savings

The electricity demand savings achievable through efficiency gains may vary significantly depending on factors such as power size, application, and product design. There is a lack of studies on the equipment degradation as a function of operation time and conditions (namely temperature, type of fluid and presence of particulate matter). The following table shows the typical savings that can be achieved by replacing old equipment with new, more efficient products.

Table 5: Typical potential savings for pumps, fans, and compressors (figures in brackets are source references)

Product Potential Savings	Potential savings [%]
Water pump [58] [66]	2%-10%
Industrial fan [58]	7%-11%
Air compressor [62]	20%-30%
Refrigeration compressor [58]	10%

The range of annual electricity savings achievable by replacing old, inefficient equipment with new, highly efficient products is shown in Figure 6. This calculation assumes that 50% of the stock has surpassed its lifetime and would benefit from early replacement.

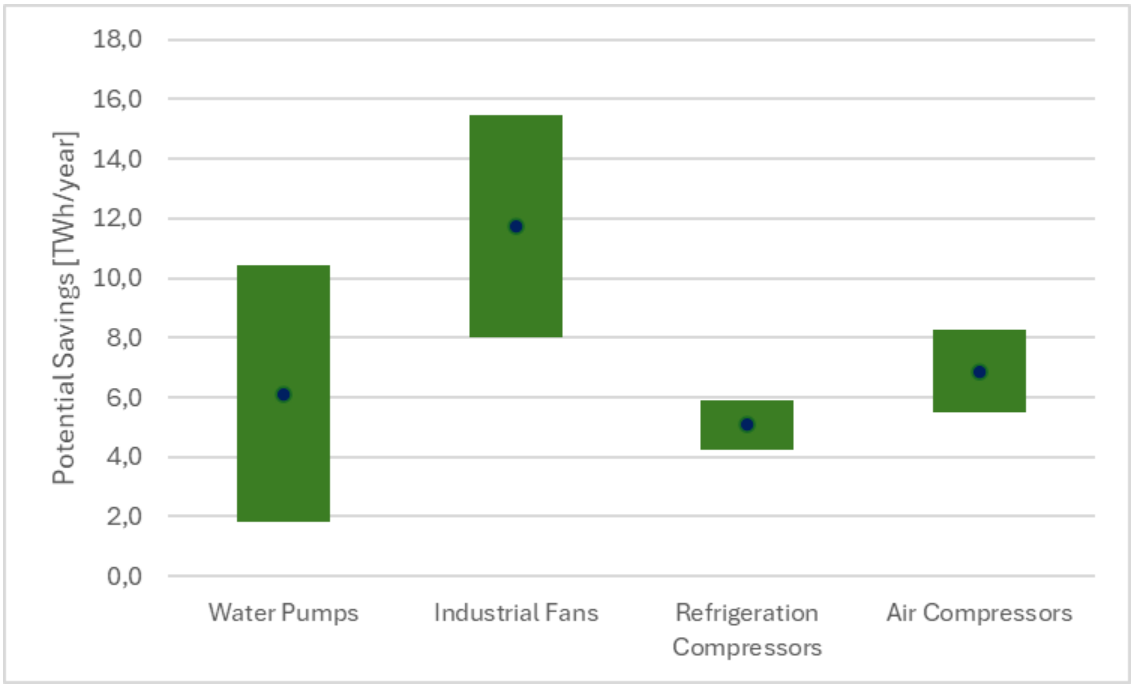

Figure 6: Range of estimated potential electricity savings from early replacement

Potential electricity savings from replacing outdated equipment with more efficient models are significant. Assuming that 50% of equipment has exceeded its operational lifetime, early replacement of inefficient equipment could yield average annual savings of approximately 29.8 TWh. As with electric motors, the savings from addressing the entire system (e.g. variable speed control; avoiding oversized equipment; minimising unnecessary bends, leaks, and pressure drops; implementing real-time monitoring with sensors to detect inefficiencies, etc.) can be much larger, which constitutes a strong argument in favour of analysing system measures at the time of replacement.

These preliminary findings highlight the importance of continued policy development to encourage the adoption of energy-efficient motor end-use technologies. Further efforts could accelerate the transition toward a more energy-efficient industrial sector, ultimately contributing to the EU's broader sustainability and carbon reduction objectives.

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