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The MORE4Sustainability Framework

A practical roadmap for Sustainable Asset Management to improve Energy Efficiency and GHG Emission Reduction

IN PARTNERSHIP WITH

BEMAS NVDO FVI EMC2 mainnovation

Interreg North-West Europe
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More4Sustainability

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Foreword

The industrial sector stands at a critical crossroad. As one of the largest consumers of fossil energy in Northwest Europe, industry plays a defining role in the battle against climate change. In recent years manufacturing activities account on average for 33% of all CO_2 emissions by economical activities and 24% of the total CO_2 emissions in Nort-West Europe. Yet, despite of the progress made, the pace of emissions reduction remains too slow to meet European and international climate targets. If the current trajectory continues, by 2050, manufacturing alone could account for half of all excess CO_2 emissions – jeopardising the broader sustainability efforts of other economic sectors.

This reality underscores an urgent need for transformation. Manufacturing industries must accelerate the adoption of sustainable technologies and operational practices. Not tomorrow, not next year, but today. Sustainability in Maintenance, Repair, Overhaul, and Engineering (MORE) is no longer just an ethical choice; it is a business necessity. Companies that integrate sustainability into their Maintenance and Asset Management strategies will not only contribute to a cleaner planet, but also unlock significant cost savings through increased energy efficiency and optimised operations.

This report presents a practical roadmap for change. The MORE4Sustainability Framework is built on real-world success stories, cutting-edge strategies, and proven methodologies that enable companies to reduce GHG emissions and improve energy efficiency without compromising reliability or profitability. You will discover best practices that leading industrial players (we call them the early adopters) are already using to future-proof their operations – ensuring compliance with regulations, reducing operational costs, and enhancing long-term competitiveness.

The question is no longer whether we should act, but how quickly we should do so. Every company has a choice: wait and struggle with mounting costs and regulatory pressure, or take proactive steps towards a more sustainable, cost-effective future.

This report is your blueprint for action. Use it. Apply it. Be part of the solution. The future of your organisation lays in your hands.

Wim Vancauwenberghe
Director, BEMAS

Management Summary

In 2019, the European Commission launched the European Green Deal, setting ambitious targets to achieve climate neutrality by 2050, including a 55% reduction in CO_2 emissions by 2030. Despite progress in industrial sustainability efforts, more action is needed, and Maintenance and Asset Management organisations must integrate sustainability into their operations to meet these critical climate targets.

The MORE4Sustianability project (2024/2025) led to a framework and a practical roadmap that enables Maintenance and Asset Management organisations to implement **Sustainable Asset Management**.

Sustainable Asset Management refers to the practice of managing industrial assets in a way that minimises environmental impact, maximises energy efficiency, and reduces GHG emissions. In the MORE4Sustainability Framework (see figure 1.6) all aspects of Sustainable Asset Management are logically presented. The Framework provides an overview of the measures that the Maintenance and Asset Management organisation can take to contribute to the company's sustainability goals, focusing on **Energy Efficiency Improvement** on the one hand and **GHG Emission Reduction** on the other.

The four quadrants of sustainable asset management are designed to be implemented in a specific sequence:

1. **Asset Portfolio Optimisation** focuses on aligning a company's assets with sustainability goals by managing the portfolio and making decisions on asset replacement based on environmental criteria.
2. **Asset Health Optimisation** improves asset performance, lifespan, and condition by using data and technology to reduce resource consumption and environmental impact.
3. **Energy Consumption Optimisation** aims to maximise energy efficiency and minimise energy waste within the processes.
4. **GHG Emission Optimisation** focuses on reducing CO_2 and other greenhouse gas emissions.

This report shows, based on input from a benchmark survey and interviews with a group of early adopters, which of these focus areas and practices and methods have the biggest impact on the previously mentioned goals and are most applied. Based on this it can be concluded that, on average, an overall sustainability improvement of 10% is achieved every three years. This shows that Maintenance and Asset Management organisations are delivering a significant contribution in reaching the EU Green Deal targets and applying Sustainable Asset Management indeed makes a difference.

To help companies with the a step-by-step implementation of Sustainable Asset Management the MORE4Sustainability Roadmap (see figure 7.1) was developed. This Roadmap contains of six steps:

1. **Step 1: Define Strategy & Targets** derived from the sustainability strategy at the company level.
2. **Step 2: Perform Self Scan & Set Actions** to identify the potential for improvement. For this purpose, the MORE4Sustainability Self Scan has been developed.
3. **Step 3: Create Business Case & Get Approval** to obtain financial justification by showing that an investment is profitable.
4. **Step 4: Build Foundation & Tactical Enablers** is about laying a foundation at the tactical level.
5. **Step 5: Execute & Monitor Action Plan** by translating each action into a project that can be managed cohesively through program management.
6. **Step 6: Evaluate & Improve Strategy** by introducing an annual improvement cycle to frequently measure the progress and costs of individual projects.

In conclusion: the MORE4Sustainability Framework offers a structured approach to integrate sustainability into Asset Management practices. While the early adopters are already reaping the benefits of improved energy efficiency and reduced emissions, the pace of change must accelerate to meet 2030 climate targets. To succeed, companies must move beyond awareness to execution. The time to act is now! Those who take decisive steps will not only secure cost savings and compliance, but will also build resilient, future-proof operations that attract investors, customers, and top talent.

Chapter 1 *Introduction*

Necessary transition to a more sustainable industry

In 2019, the European Commission made a firm commitment to combat global warming. This was expressed in the European Green Deal, which set very ambitious goals. This was a wake-up call for the industry.

The EU Green Deal mandates that European industries become more sustainable to achieve climate neutrality by 2050. By 2030, CO_2 emissions must be reduced by 55% compared to 1990 levels, and energy efficiency must improve by 32.5% compared to 2020. These measures align with the goal of limiting global temperature rise to 1.5°C above pre-industrial levels.

In Europe and beyond, many industrial companies have already started implementing sustainability improvements and Net Zero programs to meet these targets. These efforts have already yielded results: industrial energy consumption and CO_2 emissions are on the decline.

But we must do more because the current pace of progress is still insufficient to meet the 2030 and 2050 climate targets. Therefore, Maintenance and Asset Management organisations need to actively integrate sustainability into their operations. How this can be achieved is explained in this report.

Project MORE4Sustainability

Commissioned by the European Union, the project called MORE4Sustainability was carried out in 2024 and 2025. The aim of this project was to develop a framework that enables Maintenance and Asset Management organisations to improve energy efficiency and reduce CO_2 and other greenhouse gas emissions. The MORE4Sustainability Framework is a practical approach for implementing Sustainable Asset Management.

The framework is based on a thorough benchmark study of best practices in Maintenance, Overhaul, Repair & Engineering (MORE) within the manufacturing industry across Belgium, the Netherlands, France, and Germany. BEMAS (the Belgian Maintenance Association) led the project and Mainnovation, knowledge partner and experienced research agency, conducted the market research.

The consortium also included representatives from the maintenance/manufacturing societies in the four countries mentioned, namely NVDO (Netherlands), EMC2 (France) and FVI (Germany). The project drew on scientific expertise by establishing a MORE4Sustainability expert board composed of professors from technical universities in each participating country. See the acknowledgement page for a description of the societes mentioned and names of contact persons. The project was supported by Interreg Northwest Europe and cofunded by the EU.

This report provides a detailed explanation of the MORE4Sustainability Framework including an Implementation Roadmap. It gives a practical view on how companies can make an impact with Sustainable Asset Management. The report contains a self-assessment tool, a business case calculation, inspiring case studies, and benchmark results.

Sustainability regulations and scopes

European industries increasingly align their activities with sustainability goals driven by legal requirements, investor expectations, and societal demands. From the perspective of the European manufacturing sector, the following laws and regulations are considered most important:

- **UN SDGs:** the Sustainable Development Goals are the objectives for sustainable development established by the United Nations in 2015. These 17 SDGs serve as a blueprint to achieve a better and more sustainable future for all people. See boxed text for more information.
- **European Green Deal:** this EU strategy for climate neutrality by 2050, approved in 2020, focuses on achieving zero emissions, a circular economy, and energy efficiency. It encourages manufacturers to adopt cleaner technologies and Sustainable Asset Management practices.
- **Corporate Sustainability Reporting Directive (CSRD):** an EU directive that came into effect in 2023, requiring detailed sustainability reporting and ensuring transparency regarding energy consumption, emissions, and lifecycle management.
- **Science-Based Targets Initiative (SBTi):** a (voluntary) initiative for setting emission reduction targets in line with EU goals. It pushes industries to invest in low-carbon assets and to improve energy efficiency to meet climate objectives. By early 2025, over 10,000 companies worldwide have joined this initiative.

By formulating the SDGs, the UN member states aim to ensure a future of prosperity and peace for people and planet. The scope is much broader than just the industry, and the goals include far more than improving energy efficiency and reducing greenhouse gas emissions (see figure below).

In the research, we asked which of the 17 SDGs are most important to the participating companies. Among all other sustainability goals, particular attention is given to the implementation of:

- Good Health and Well-being
- Responsible Consumption and Production
- Industry, Innovation, and Infrastructure
- Climate Action

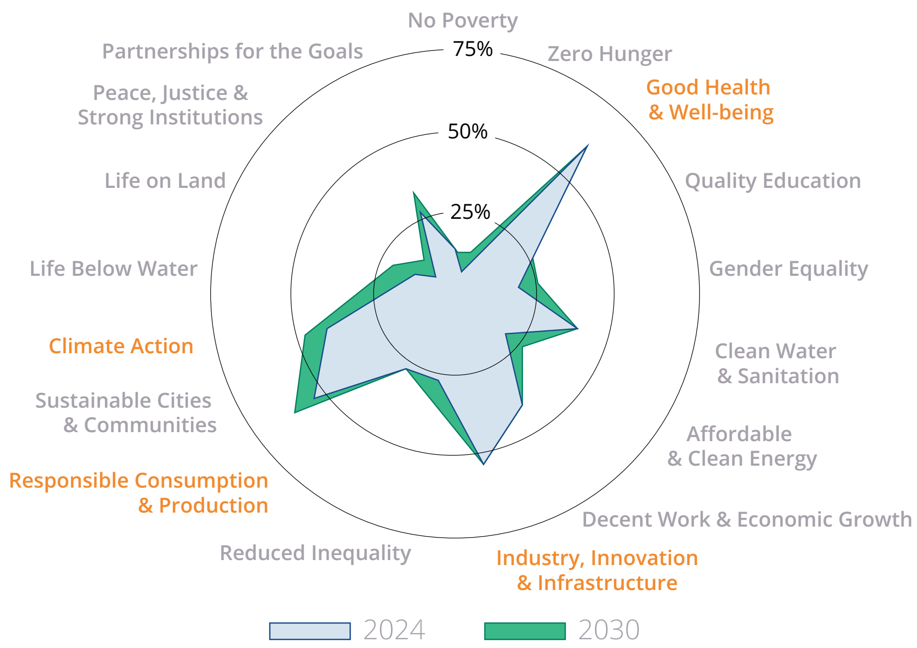


Figure 1.1 | Implementation degree of strategy practices.

The UN SDGs, the European Green Deal, and SBTi promote decarbonisation and improved energy efficiency, while CSRD ensures transparent reporting and accountability.

Together, they create a cohesive approach to Sustainable Asset Management, enabling organisations to reduce environmental impact, comply with regulations, and gain a competitive advantage.

A commonly used term when it comes to sustainability is ESG, which stands for Environment, Social and Governance. We also asked the early adopters about the reporting pressure for sustainability. How does the perceived pressure compare to the reporting pressure for Maintenance and Asset Management?

In general, early adopters currently experience the reporting pressure as "low" or "average". This is explained by the fact that many participating organisations do not yet have concrete sustainability reporting for Asset Management (see figure 1.2).

Within the domain of Social Responsibility, questions were asked about considering sustainability when purchasing external capacity and materials.

When asked if sustainability is taken into account when hiring external capacity through contractors, over 75% of the early adopters answered that this is indeed the case. 35% of participants do this only for contractors with a high impact on sustainability, while over 40% apply this to all contractors (see figure 1.3).

For the purchase of materials, in 71% of cases, sustainability criteria are used in the assessment when it concerns materials with a high sustainability impact. Approximately 30% applies this to all materials to be purchased (see figure 1.4).

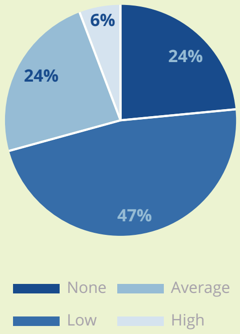


Figure 1.2 | Reporting impact on sustainability.

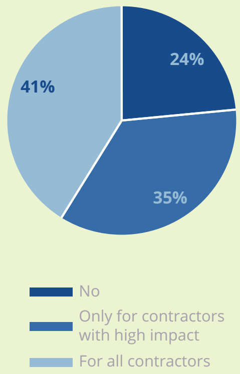


Figure 1.3 | Sustainability when contracting resources.

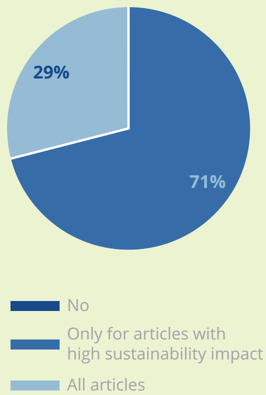


Figure 1.4 | Sustainability when purchasing articles.

In addition to various laws and regulations, in 1998 also the Greenhouse Gas (GHG) Protocol was introduced. This is the international standard for quantifying greenhouse gas emissions. Within this protocol, three types of emissions are distinguished when calculating an organisation's carbon footprint, known as **Scope 1**, **Scope 2**, and **Scope 3**.

Figure 1.5 | The different types of Scopes.

Scope 1 includes all direct greenhouse gas emissions generated by sources owned or controlled by the organisation. These are emissions from combustion processes or industrial processes within the factory.

Scope 2 relates to indirect greenhouse gas emissions resulting from the generation of purchased electricity, heat, steam, or cooling consumed by the factory. These emissions occur during the production of energy generated elsewhere but used by the factory.

Scope 3 encompasses all other indirect emissions resulting from the organisation's activities but occurring at sources not controlled by the organisation. This includes emissions across the entire value chain, such as those from suppliers, product use, and the processing of sold products. Scope 3 is often the largest source of emissions and can be complex to measure.

The focus of the MORE4Sustainability Framework (see next paragraph) predominantly lies on Scope 1 and Scope 2. It helps companies to reduce the direct GHG emission of their factories (Scope 1) and to improve the energy efficiency of their fossil fuel driven equipments (Scope 1) and electrical equipments (Scope 2).

MORE4Sustainability Framework

Central to this project was the development of a framework in which all aspects of Sustainable Asset Management are logically presented. The MORE4Sustainability Framework provides an overview of the measures that the Maintenance and Asset Management organisation can take to contribute to the company's sustainability goals, focusing on Energy Efficiency Improvement on the one hand and GHG Emission Reduction on the other.

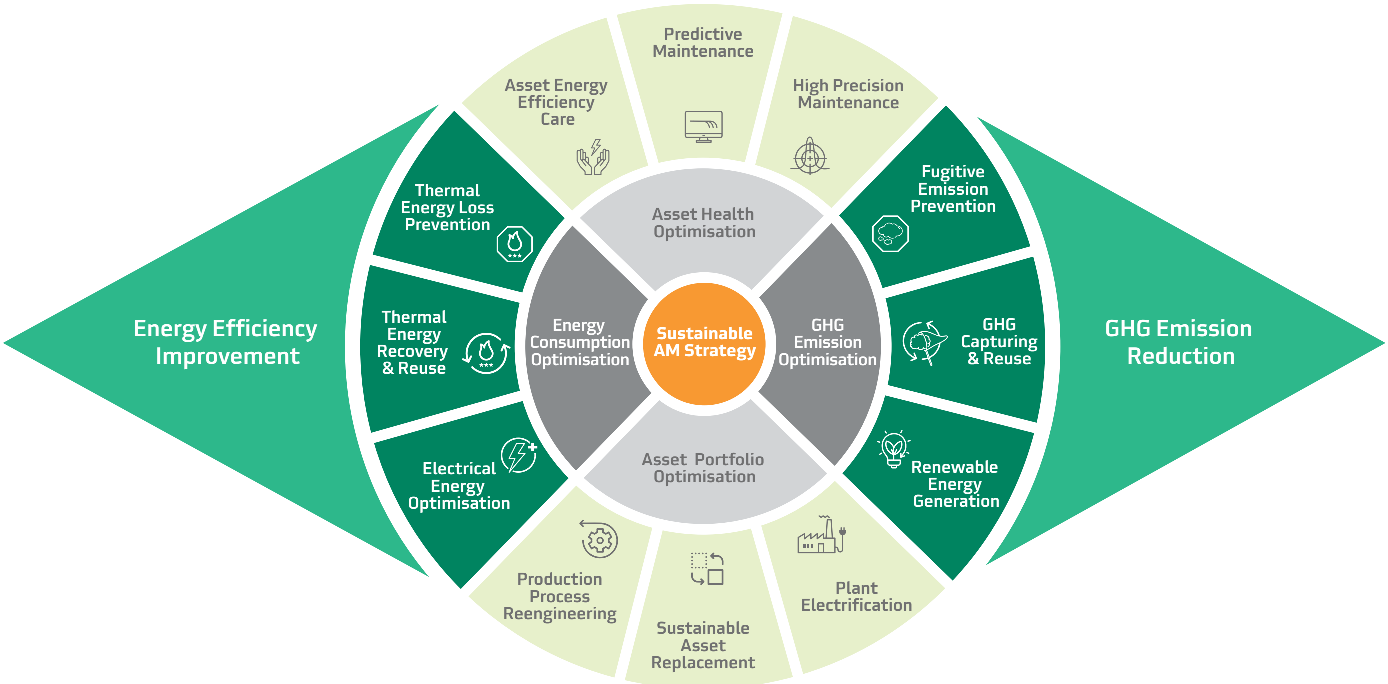


Figure 1.6 | The MORE4Sustainability Framework.

This MORE4Sustainability Framework consists of four levels:

- Strategic level (the orange area) where the company's sustainability strategy is translated into the Asset Management strategy. This includes mission, vision, and relevant laws and regulations.
- Tactical level (the gray area) describes four quadrants focused on optimisation: Asset Portfolio Optimisation, Asset Health Optimisation, Energy Consumption Optimisation, and GHG Emission Optimisation. These quadrants set the right direction and provide a basis for working on sustainability optimisation and integrating best practices.
- Operational level (the areas in lime and dark green) in which twelve focus areas are defined that are elaborated into practices and methods.
- The fourth level describes the impact of the measures (the green areas on the left and right) on the two sustainability goals: Energy Efficiency Improvement and GHG Emission Reduction.

The four quadrants also entail a specific sequence.

1. **Asset Portfolio Optimisation**, with a focus on sustainability for production, involves strategically managing a company's portfolio of physical assets to achieve environmental, social and economic sustainability goals. It also involves monitoring sustainability risks throughout the asset life cycle, making optimal decisions to replace assets, and defining and applying internal sustainability criteria.
2. **Asset Health Optimisation**, for sustainability reasons at the tactical level, involves implementing specific strategies, IT systems, management systems and actions aimed at improving asset condition, performance and lifespan, while minimising environmental impact and resource consumption. It also involves using data, technology and analytics to monitor, assess and optimise the health and performance of assets throughout their life cycle.
3. **Energy Consumption Optimisation** refers to the process of maximising energy efficiency and minimising energy waste in various systems, processes and activities within an organisation or facility. The goal of Energy Consumption Optimisation is to achieve the desired level of performance or output with as little energy consumption as possible.
4. **GHG Emission Optimisation** for sustainability reasons at the tactical level, involves implementing specific strategies and actions aimed at minimising greenhouse gas (GHG) and other pollutant emissions generated during production processes.
   By implementing GHG Emission Optimisation strategies, organisations can reduce their carbon footprint, improve sustainability performance and contribute to a cleaner, greener future.

The order of these quadrants from 1 to 4 is also the sequence in which these sustainability measures should logically be implemented. It is advisable to first bring the asset portfolio in order and replace non-sustainable installations with sustainable ones. Subsequently, the sustainability of the machines can be improved through proper maintenance and alignment, as this will result in lower energy consumption. Step 3 involves optimising energy consumption. Once this is in place, steps can be taken in the final phase to reduce emissions, for example, through CO_2 storage or reuse or the installation of wind turbines.
This sequence adds a meaningful new dimension to the "4" in the project name MORE4Sustainability.

Chapters 3 through 6 provide further elaboration on the aforementioned quadrants.

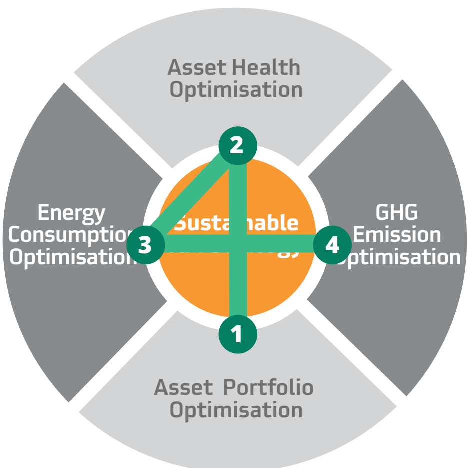


Figure 1.7 | The four quadrants of the Sustainable Asset Management Framework.

Insights from the benchmark study

Scope benchmark study

For this project, representatives from companies in the manufacturing industry (asset owners and solution providers) were invited to participate in the MORE4Sustainability benchmark study. Data from approximately 80 companies were analysed to compile an overview of effective sustainability measures.

Among the asset owners, 20 companies were identified as the early adopters. These companies were approached for in-depth interviews to provide detailed information on the impact, motivations for implementation, and results of applied practices. The collected input was analysed and incorporated into this report.

Additionally, all information will be used to shape the extensive training program offered in 2025 (and beyond). This program will be executed in Belgium, France, Germany and The Netherlands and will provide manufacturing companies, solution providers, and all Maintenance and Asset Management professionals tools to actively pursue sustainability goals.

When examining the benchmark survey results and insights from the in-depth interviews with early adopters, it can be concluded that, on average, an overall sustainability improvement of 10% is achieved every three years (see figure 1.8).

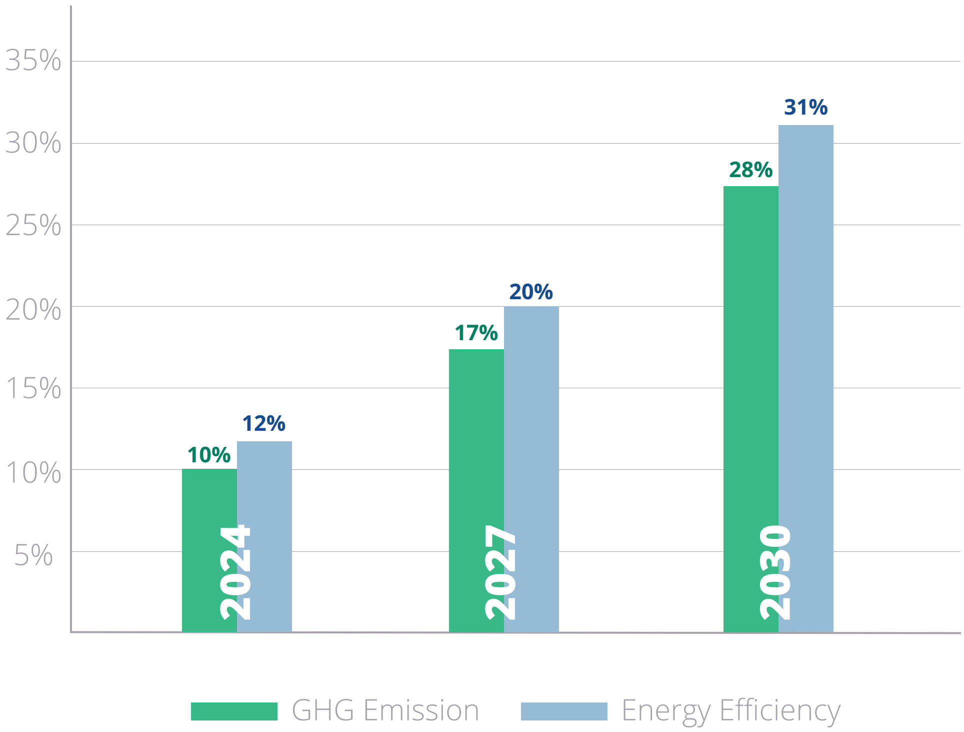


Figure 1.8 | The overall sustainability improvements 2024-2030 compared to 2020.

A 10% improvement every three years means that Maintenance and Asset Management organisations are delivering a significant contribution in reaching the EU Green Deal targets. However, to really achieve these targets, it remains essential to implement sustainability measures also outside the Maintenance and Asset Management domain, in processes like production, procurement, and transportation.

At figure 1.8, we see that greater results are achieved in Energy Efficiency Improvement compared to GHG Emission Reduction. This is because companies already increasingly use clean/green energy. When energy consumption decreases but the energy was already green, energy efficiency improves while GHG emissions remain unchanged at “0.”

It was already known that the industry in Northwest Europe is one of the largest users of fossil fuels. The necessity for sustainability is therefore evident. This study confirms that average energy consumption per asset replacement value (ARV) and GHG emissions per ARV are high in the industry. Early adopters report an average energy consumption of 1.1 GJ per € 1,000 invested in assets.

To relate this to CO_2 emissions, the average CO_2 emissions per GJ of energy used in the industry are considered. This varies by country due to differences in energy mix composition (natural gas, green electricity, gray electricity, nuclear power, wind energy). The average emissions in the Netherlands and Belgium are 70 grams of CO_2 per MJ of energy.

Using this data, it can be calculated that for the interviewed companies, emissions amount to 0.073 ton of CO_2 per €1,000 invested in their asset portfolio.

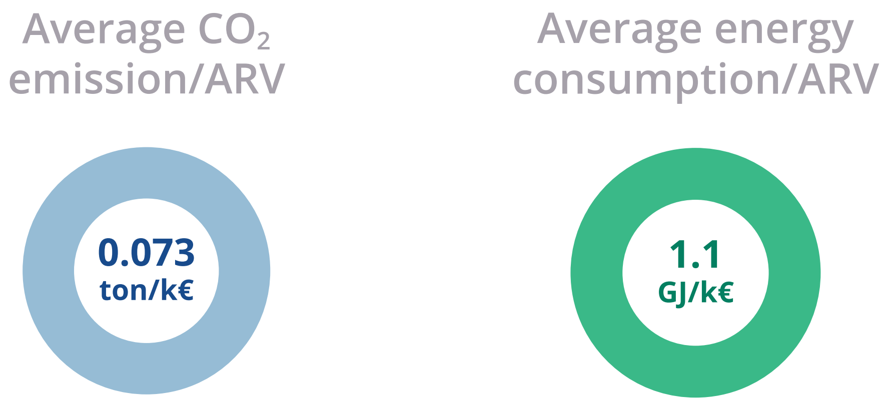


Figure 1.9 | Energy Consumption and CO_2 Emissions per € 1,000 ARV.

When focusing on Energy Efficiency and examining results in 2024 within the four quadrants, most impact is achieved through Asset Portfolio Optimisation and Asset Health Optimisation. However, Energy Consumption Optimisation will become increasingly important in the future (2027–2030).

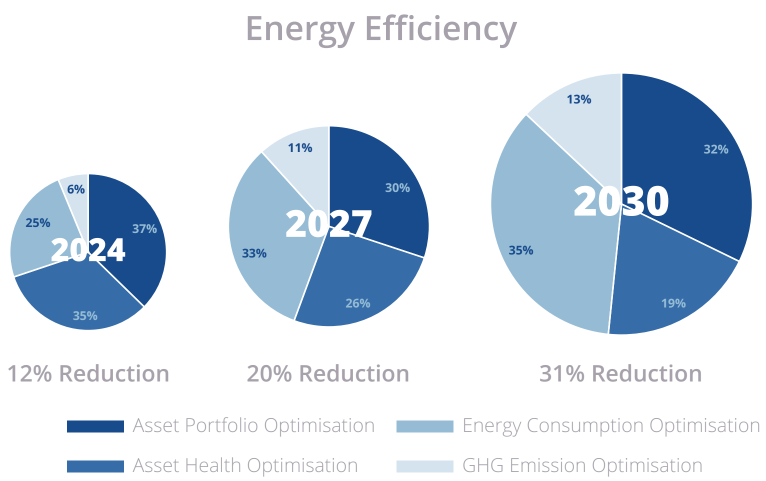


Figure 1.10 | Improvement from 2020–2030 in Energy Efficiency (reference year: 2020).

In terms of GHG Emission Reduction, most impact in 2024 is made through Asset Portfolio Optimisation, with lesser contributions from Asset Health Optimisation and Energy Consumption Optimisation. However, GHG Emission Optimisation will gain importance in the future.

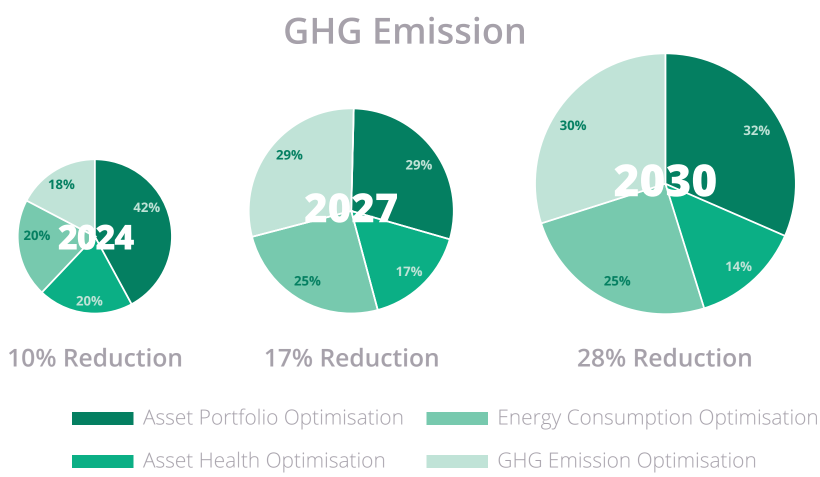


Figure 1.11 | Improvement from 2020–2030 in GHG Emission Reduction (reference year: 2020).

This confirms that early adopters follow the 4-step sequence displayed in figure 1.7. The four quadrants within the framework represent a logical step-by-step plan. However, it is noted that implementation does not necessarily need to follow this sequence strictly and may occur incrementally or concurrently.

More detailed information can be found in the specific chapters covering various aspects of the MORE4Sustainability Framework.

Chapter 2 *Sustainable Asset Management Strategy & Tactics*

Developing a Sustainable Asset Management Strategy

Implementing Sustainable Asset Management starts at the heart of the framework (figure 1.6) by developing a Sustainable Asset Management strategy. This strategy should be derived from the sustainability strategy at the company level. What sustainability goals have been set at corporate level, and how can the Maintenance and Asset Management organisation contribute to these goals? This involves the following elements:

- **Mission and vision**
  Aligning the Asset Management organisation's mission and vision with the company's sustainability principles ensures that sustainability becomes part of the identity and purpose of the Maintenance and Asset Management organisation.
- **(Legal) Compliance and standards**
  It's important to comply with relevant sustainability regulations, standards, and best practices, and to stay informed about trends and developments in Sustainable Asset Management.
- **Performance measurement and reporting**
  This involves setting goals and Key Performance Indicators (KPIs) to measure the sustainability performance of the organisation and its assets, and to regularly report on progress. To set the right priorities, it must be clear how these objectives relate to other goals of the Maintenance and Asset Management organisation. Among early adopters, sustainability is in the top three, but it is not more important than safety and asset availability (see figure 2.1).

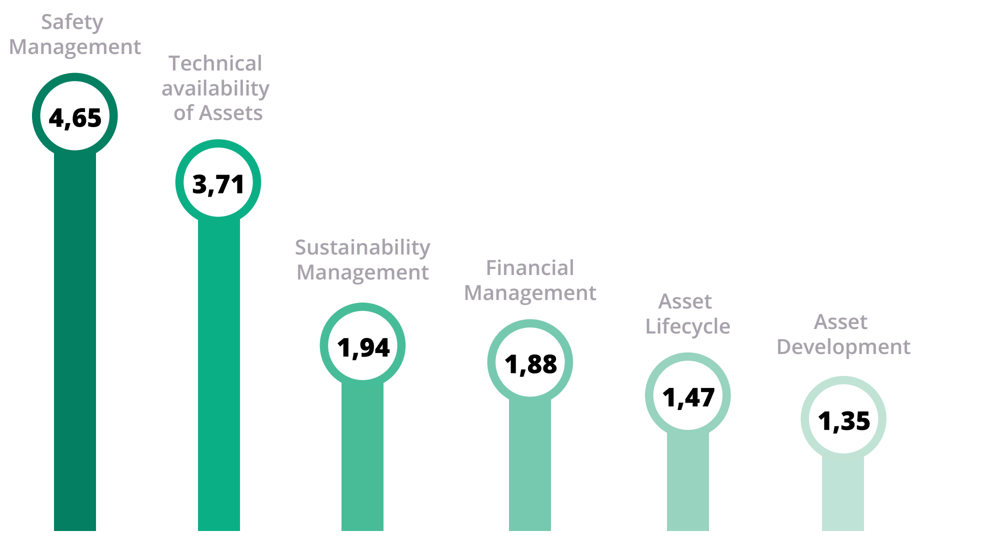


Figure 2.1 | Importance of Sustainability in Asset Management on a scale of 1 to 6 (lowest to highest priority).

- **Sustainability culture**
  Creating a sustainability culture within the organisation implies promoting a mindset, values, and behavior that prioritise ecological, social, and economic responsibility.

Figure 2.2 shows that the early adopters understand the necessity of having a Sustainable Asset Management strategy, although not all companies have fully developed all four of these elements yet. They plan to do so in the coming years.

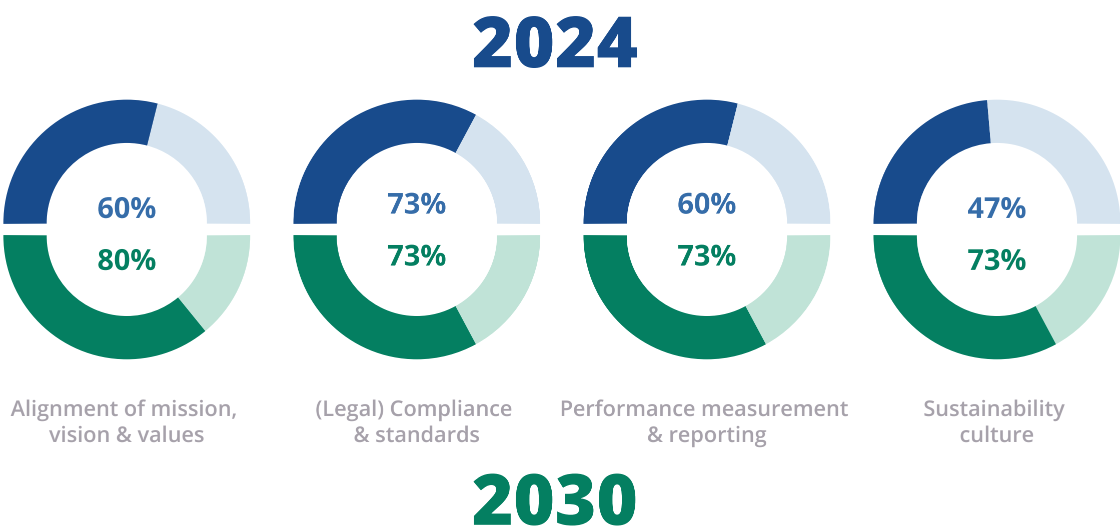


Figure 2.2 | Implementation degree of strategy elements.

Translating strategy into tactics

Once the sustainability objective for the Maintenance and Asset Management organisation is clear, it must be determined how these goals can be achieved. In the MORE4Sustainability Framework, we distinguish four quadrants that can be used for this. Each company must determine which quadrants are most relevant.

Each quadrant is associated with certain preconditions, a basis that must be met in order to actually apply practices. We call these “the enablers”. It’s important to properly set up the five enablers within the quadrants, as they form a foundation for using MORE4Sustainability as a working method. These enablers are:

- **Processes:** what structured approach does the company want to use within the different quadrants to better manage risks, implement targeted improvement actions, and achieve lower environmental impacts?
- **Standards:** which standards (ISO or others) can be used?
- **Tooling:** what IT systems (tools, software, and other technologies) are needed for the new way of working?
- **Training:** what education, skill development, and knowledge expansion is needed for employees to implement the new approach?
- **Artificial Intelligence:** how could AI make the new approach more efficient and effective?

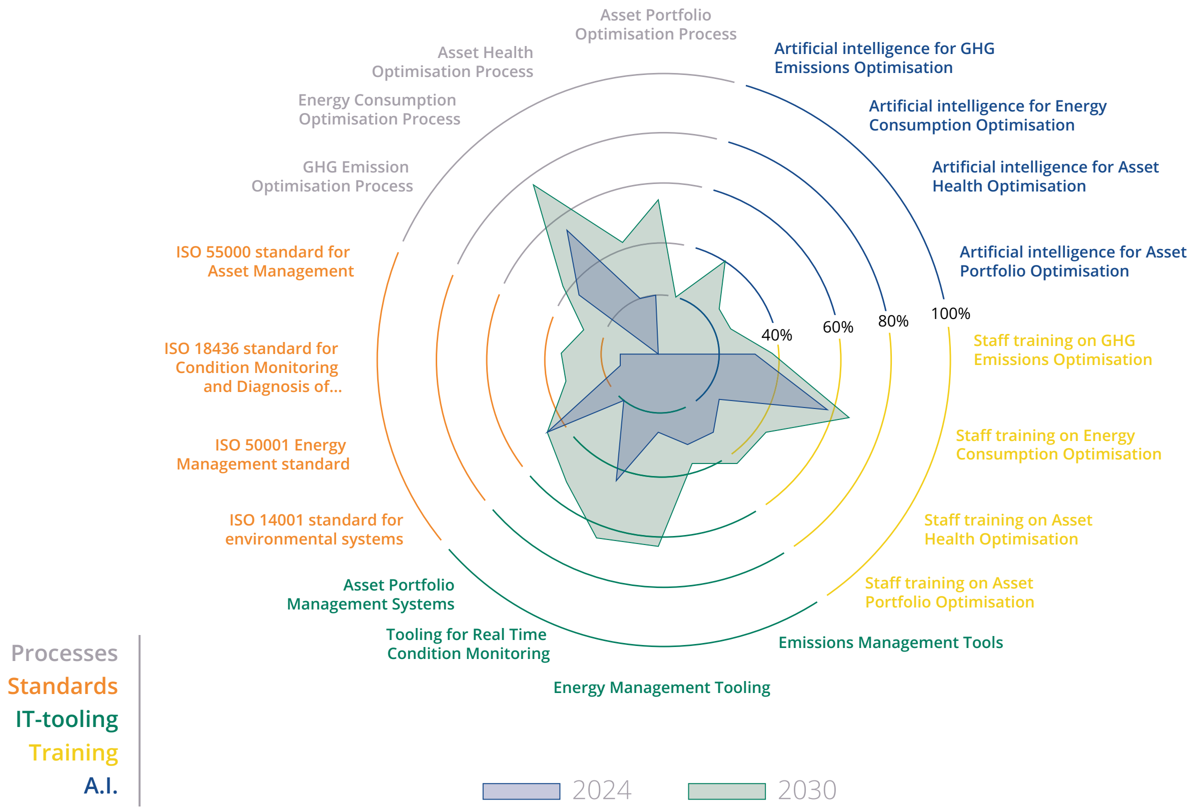


Figure 2.3 | Implementation degree of enablers.

The benchmark survey results show that in 2024, the early adopters are still busy implementing these enablers (see figure 2.3). Looking at plans for 2030, the following stands out:

- Process optimisation is mainly needed for Energy Consumption Optimisation. For the other quadrants this is less relevant, although it will increasingly play a role in Asset Portfolio Optimisation in the future.
- ISO 14001 (the standard for environmental management systems) is seen as the most important ISO standard for Sustainable Asset Management. The ISO standard for Asset Management (55001) is the least used ISO standard for this theme. A new chapter on sustainability was added to the standard in early 2024, but this may not have been known at the time of this study.
- IT tooling is especially needed for the Asset Health Optimisation quadrant, mainly for condition monitoring systems. Tools are also used in the Energy Consumption Optimisation quadrant to monitor, analyse, and optimise energy consumption (energy management systems).
- The need for training is mainly seen in the field of Energy Consumption Optimisation. For other quadrants, the required skills are often already in-house.
- Artificial Intelligence will mainly be used in Energy Consumption Optimisation for automatically optimising machine energy consumption. Surprisingly, this is less expected for Asset Health Optimisation, where AI could also play a role in predictive maintenance applications.

For each quadrant, the right foundation must be established at the tactical level to achieve the desired improvements at the operational level. These improvements are explained per quadrant in the next four chapters.

Sustainability is a must do

"We want to pass on a more sustainable company to future generations"

Case Story

As a family business, Royal Swinkels – producer of malts, beers and non-alcoholic drinks – has an extra strong drive for sustainability. The mission is to pass on a better company to future generations. That is why sustainability has been high on the agenda for years.

Strategy

Within the MORE4Sustainability Framework, determining the right strategy is an important first step. A clear mission and vision are crucial for this. In terms of sustainability, Royal Swinkels has been considered a leader for quite some time. Tessa Junggeburth, Program Manager Sustainability, says: “Higher targets are set every year. For example, the share of sustainable transport is expanded annually; our packaging, the buildings that we build or give a new purpose, or the share of recycled content of newly purchased machines.” So, Royal Swinkels has a very clear climate ambition. “This is underlined by the fact that our goals have been validated by the SBTi.”

Three core processes

Sustainability is a broad concept. Royal Swinkels is focussing mainly on circularity. “We want to be a frontrunner in this area.” In the context of fully circular entrepreneurship, Royal Swinkels has developed its own method: the Swinkels Circularity Index. Junggeburth: “This is how we measure circularity. We do this within three core processes: circular purchasing, circular production and high-quality reuse.”

The production phase is about using as little energy, water and chemicals as possible. “If we buy a machine that uses less energy, this has a positive impact on the index. This index is provided with accountancy assurance and is part of our annual report. This makes our index unique.”

Asset Management

Not replacing is of course the most sustainable thing to do. Junggeburth: “One way to pursue sustainability goals from Maintenance and Asset Management is to extend the lifespan. The best thing you can do in terms of circularity is not to throw something away, not to break it down. For example, by monitoring the condition, reliability engineering and by doing maintenance properly, you contribute to extending the lifespan.”

But according to Junggeburth, the challenge of improving energy efficiency is also a responsibility of the asset manager. “Using as little energy as possible is about which machines you choose, but also about adjusting them properly, maintaining them well and using them correctly, because they then consume less energy.”

Chain responsibility

Junggeburth also sees developments in the chain. “We are increasingly receiving questions from customers and suppliers who ask us to become more sustainable. Our products must become increasingly sustainable and their CO_2 footprint must be reduced. We have specific goals to significantly reduce our Scope 1 emissions in the coming years; new technological solutions and new assets are being developed to achieve this and the maintenance organisation will have to manage and maintain these as optimally as possible.”

In this way, Royal Swinkels strives to further reduce the ecological footprint and indeed to pass on a healthier and more sustainable company to the next generations.

⇒ Source: royalswinkels.com

Chapter 3 *Asset Portfolio Optimisation*

The first quadrant in the MORE4Sustainability Framework focuses on optimising the machinery park with the aim of improving energy efficiency and reducing GHG emissions. This ranges from replacing individual "dirty" machines to completely redesigning and rebuilding the production process.

This is a fundamental step where the company strategically evaluates its entire portfolio of physical assets from a sustainability perspective. The subsequent replacement of unsustainable machines often involves large investment projects, with direct impact on sustainability. This explains why Asset Portfolio Optimisation is the quadrant with the highest contribution to Energy Efficiency Improvement and GHG Emission Reduction (see figures 1.10 and 1.11).

Within the MORE4Sustainability Framework, we distinguish three focus areas in this quadrant: Sustainable Asset Replacement, Plant Electrification, and Production Process Reengineering. The benchmark study shows that Sustainable Asset Replacement is most frequently applied within this quadrant and has the most impact.

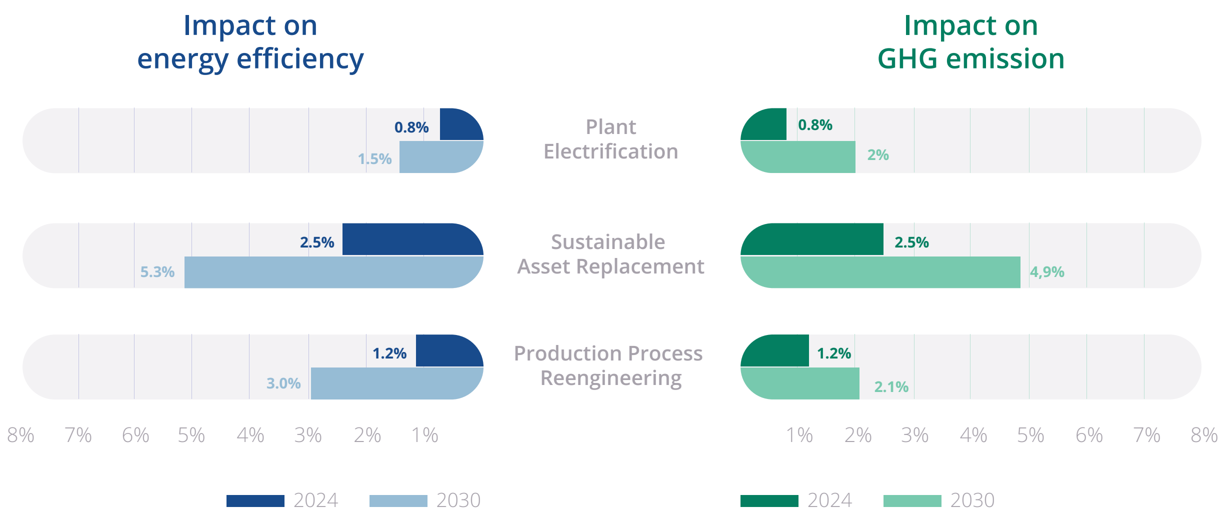


Figure 3.1 | Impact of Asset Portfolio Optimisation.

Sustainable Asset Replacement

Sustainable Asset Replacement refers to replacing or upgrading existing assets, such as equipment, machines, or facilities, with more sustainable and environmentally friendly alternatives using the same type of energy source, but with better energy efficiency characteristics. This is also called like-for-like. The goal is to improve the overall sustainability of operations while ensuring functionality.

Replacing “dirty” machines with “clean” machines, that have high energy efficiency and low GHG emissions, is the simplest way to work on sustainability. For many companies, this is a first step towards becoming more sustainable. This often happens when the old machine has reached end-of-life. By choosing this moment, the extra investment in sustainability is not so high, because the replacement had to be done anyway.

Because many factories in Northwest Europe are dealing with aging assets, there are opportunities to put this into practice. This is one of the reasons why Sustainable Asset Replacement has the highest impact within this quadrant.

Within this focus area, we distinguish the following practices:

- **LED lighting** involves replacing traditional lighting solutions (such as incandescent, fluorescent, and halogen lamps) with LED lighting technology.
- **Smart and adaptive lighting** refers to advanced lighting systems that adjust the level and quality of light in an environment based on various factors, such as the availability of natural light, occupancy, time of day, and specific user preferences or activities (see EcoNation case story on the next page: “Light catchers minimise electricity use”).
- **High-efficiency HVAC systems** provide heating, cooling, and ventilation with significantly greater energy efficiency compared to standard HVAC systems.
- **High-efficiency motors and drives** are essential components in various applications that operate with minimal energy losses, maximising efficiency and reducing electricity consumption.
- **Life extension, refurbishment, and overhaul** significantly improve the sustainability of machines by prolonging the life of equipment, reducing the need for new materials, minimising waste production, and enhancing energy efficiency.
- **Circularity for sustainable replacement** involves rethinking how assets are replaced, emphasising minimising environmental impact, maximising using existing resources, and ensuring that materials at the end-of-life are effectively reused or recycled.

Case Story

Light catchers minimise electricity use

EcoNation is a Belgian company that specialises in the development, production and installation of intelligent daylight systems. The company created the "LightCatcher", an advanced technology designed to make more efficient use of natural daylight in factories, warehouses and other buildings.

This system uses a smart skylight equipped with a mirror system that automatically points towards the best light source, usually the sun. The system captures daylight, then filters and amplifies it through a light shaft, allowing more natural light to enter the room.

The first advantage of the system is energy savings. By maximising natural light in a factory, the LightCatcher reduces reliance on artificial light, leading to a significant reduction in energy consumption and CO_2 emissions. Reduction of artificial light consumption results in considerable savings on maintenance of the lighting installation too.

Also, the skylight and lenses add two layers of non-circulating air, which offers an optimal insulating effect and prevents heavy temperature fluctuations. As a result, additional savings on heating in winter and cooling in summer can be achieved.

Carglass's European distribution center in Genk (Belgium) installed EcoNation LightCatcher, including a lighting control system to measure the daylight level. When sufficient natural daylight enters the warehouse, the artificial light is dimmed and even extinguished. With 422 LightCatchers in its 40,000 m² warehouse, approximately 175 MWh per year is expected to be saved annually. This is equivalent to 2,190 burning hours of conventional lighting systems or 57.4 ton CO_2 emissions.

⇒ Source: www.econation.be

The benchmark study shows that LED lighting is most frequently chosen for implementation. This can be explained by the relatively low investments and the simplicity of the intervention. The use of high-efficiency motors and drives is also a technique that is already widely employed.

We also see that companies consider lifetime extension and circularity for Sustainable Asset Replacement as serious alternatives to reduce environmental impact. It is worth noting that these measures primarily impact Scope 3 and not so much Scopes 1 and 2 (see chapter 1 for an explanation of the Scopes).

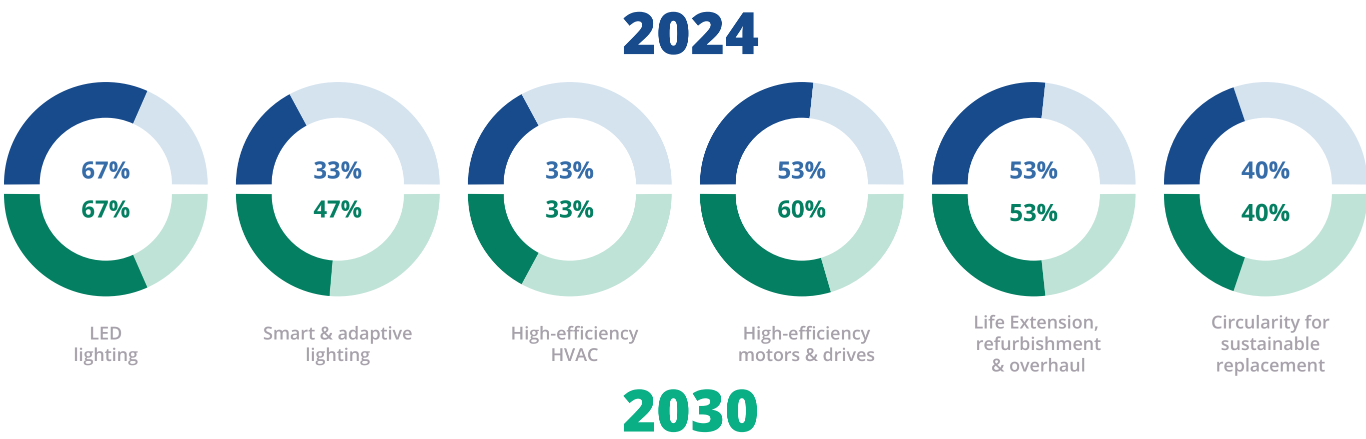


Figure 3.2 | Implementation degree practices Sustainable Asset Replacement.

Plant Electrification

Plant Electrification refers to the process of transitioning from traditional fossil fuel-based energy sources to electrical energy. This involves replacing or supplementing mechanical systems and machines powered by fossil fuels with electrically powered alternatives. For instance:

- **Electric pumps**
- **Electric compressors**
- **Electric heating elements**
- **Electric vehicles and forklifts**

This latter practice involves the transition to electric vehicles (EVs) or electric forklifts for the transportation and handling of goods. In facilities with transportation needs, plant electrification can also be achieved in this way. This reduces emissions from combustion engines and improves air quality within the facility. The benchmark study shows that this is a frequently applied method, just like the use of electric compressors.

However, overall, the impact of Plant Electrification is relatively low (see figure 3.1), despite its popularity. This is because many companies had already started with Plant Electrification before 2020, particularly for motors. As a result, during the period from 2020 to 2024, the impact on Energy Efficiency Improvement and GHG Emission Reduction is less significant because the maximum efficiency had already been achieved in the past.

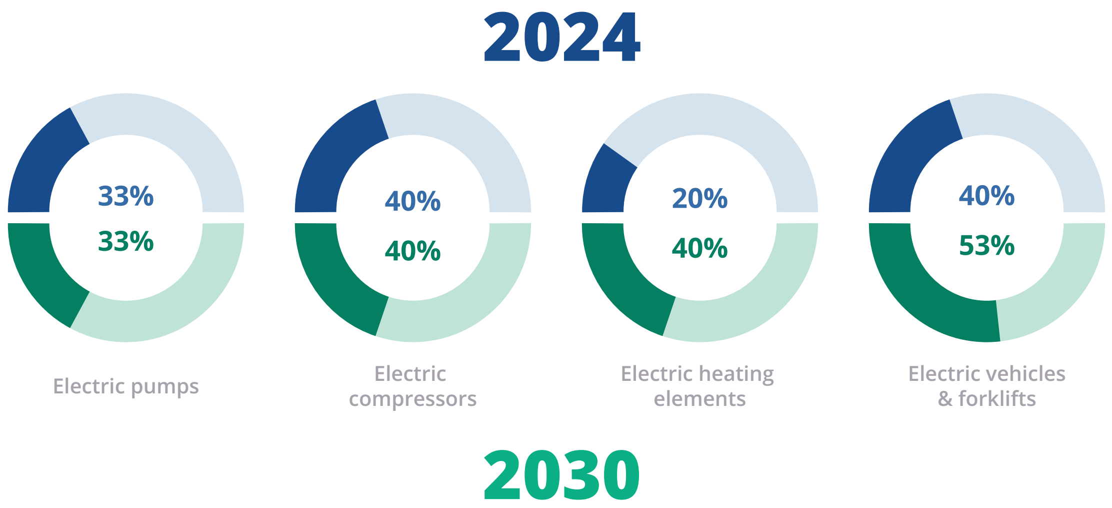


Figure 3.3 | Implementation degree practices Plant Electrification.

Case Story

World's first hybrid glass furnace to reduce CO_2 emissions

"Making the world a better home" is **Saint-Gobain**'s credo. That is why the company has set itself the goal of being energy neutral by 2050. In October 2024, subsidiary Isover Netherlands, producer of insulation materials, took a major step towards achieving these corporate objectives: the outdated gas furnace, which was used to produce glass wool, has been replaced by a brand new, hybrid glass furnace.

The new furnace in Etten-Leur is the world's first hybrid glass furnace with up to 50% electric heating. The glass wool produced here consists of 50 to 70% recycled glass. A good start of a sustainable production process that is certified according to ISO 14001.

The glass furnace is heated for 50% by electricity. This heat comes from electrodes at the bottom of the furnace. The remaining heat requirement is met by gas in combination with pure oxygen. The improvements compared to the gas furnace are significant. For example, the CO_2 emissions of the furnace were reduced by no less than 55%. The new installation also means a reduction in the gas consumption of the furnace by 55% and an overall reduction in the energy consumption of the furnace of 26% is achieved.

This is a major step towards becoming energy neutral: a reduction in the total CO_2 emissions of the factory by 20% in 2025 compared to 2010.

This Hybrid Furnace Project was made possible in part by 'The Innovation Fund' of the European Union. Other factories within the Saint-Gobain network can quickly follow. In addition, the technology can lead to a reduction in the CO_2 emissions of other manufacturers in the sector, with a global impact.

⇒ Source: www.isover.nl/nieuws/

Production Process Reengineering

For some companies, replacing or electrifying individual machines is insufficient to meet sustainability goals. In that case, the entire production process needs to be optimised.

Production Process Reengineering involves fundamentally redesigning and optimising production processes to achieve significant improvements in environmental sustainability. This approach aims to streamline activities, minimise resource consumption, and reduce GHG emissions and energy use, while maintaining or improving product quality and competitiveness.

This includes the following practices:

- **Process optimisation and redesign** means introducing technology upgrades and automation to minimise energy consumption, greenhouse gas emissions, and waste production, while maintaining or improving productivity and product quality.
- **Product conversion** is the process of switching the production line from manufacturing a product to another, more sustainable product. This process may involve various steps and adjustments to machines, equipment, and operational setups to meet the specifications and requirements of the new product and improve sustainability performance.
- **(Partial) Plant closure** refers to the shutdown of (part of) the operations of a production facility or factory. This could be for a variety of reasons, including restructuring of operations, reduction in demand for certain products, maintenance or upgrades of specific parts of the plant, or sustainability issues that lead to a scaling back of operations.
- **Building a (partial) new factory** means building an extension to an existing production facility or an entirely new factory. This approach is used to expand production capacity, introduce new product lines, and/or adapt to new production technologies with the aim of improving sustainability performance (see the Tata Steel case story about the Heracless project).
- **Circularity from process reengineering** refers to fundamentally rethinking and redesigning production processes with the goal of minimising waste, maximising resource efficiency, and creating sustainable products with a longer life cycle.

Case Story

Steel production without using coal

Tata Steel IJmuiden (the Netherlands) is Tata Steel's largest production location in Europe. The company mainly produces coils of high-quality and coated steel that is used in the automotive industry, construction and the packaging industry. It has expressed the ambition to produce hydrogen-based green steel by 2030 and produce completely CO_2-neutral steel by 2045 without compromising on quality.

The mission for the years to come is to transform into a clean, green, and circular steel company. With this transition to green steel, Tata Steel is one of the steel companies in Europe that is saying goodbye to steel production using coal.

The project with which Tata Steel wants to shape the transition to 2030 is called the H2-era-C-less-Green Steel project. In short: Heracless-Green Steel. The main objective of the project is to reduce its annual CO_2 emissions by 5 million tonnes by 2030. This is approximately 20% of the target for Dutch industry as a whole.

The first stage of the project will go into operation by as soon as 2030 and consists of the realisation of 1 Direct Reduction Plant (DRP) and 1 Electric Arc Furnace (EAF) to replace the Blast Furnace 7 and Cokes and Gas Plant 2 (KGF2). This means 40% less CO_2 emissions. The company also wants to take measures to further reduce emissions and particulate matter, and use more scrap in the production of steel (from 17% to 30%).

In the second phase of its transition, Tata Steel aims to close Blast Furnace 6 and Cokes and Gas Plant 1 (KGF1), which will result in a total CO_2 reduction of approximately 80%. In the following years towards 2045, Tata Steel will become completely CO_2 neutral.

⇒ Source: https://www.noord-holland.nl/bestanden/pdf/NRD%20Heracless.pdf

The benchmark study shows that in 2030 about 50% of the early adaptors will have reengineered their production process in order to meet sustainability goals. About 25% of the early adaptors will build a new (part of the) factory. The same percentage has plans to modify the factory and switch to another product.

In extreme cases, a partial or entire shutdown of the plant operations would eliminate that site's emissions entirely. But this is certainly not a desirable solution. This is currently considered an option by 7% of the early adopters. Nevertheless, many early adopters do complain about increasingly strict regulations and high energy costs.

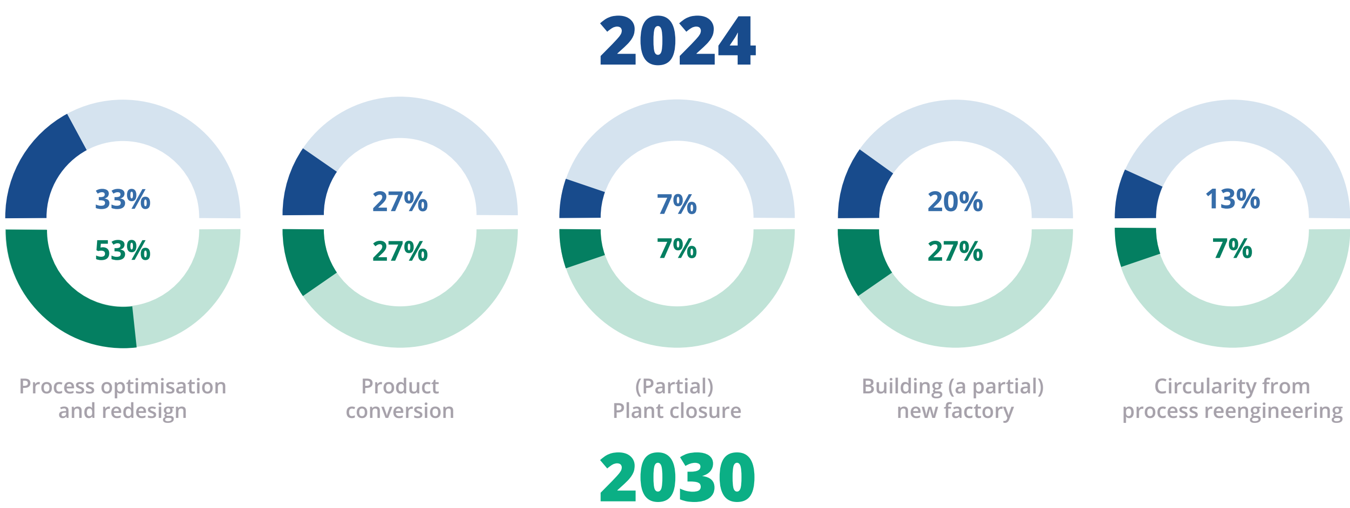


Figure 3.4 | Implementation degree practices Production Process Reengineering.

Chapter 4 *Asset Health Optimisation*

The first quadrant, as described in Chapter 3, focuses on the installation of sustainable machines and the transformation toward a sustainable production process. The second quadrant - Asset Health Optimisation - concerns the proper maintenance of these machines.

Proper maintenance, aimed at optimising asset health for sustainability reasons, involves improving the condition, performance, and lifespan of assets while minimising their environmental impact. After all, we know that a well-maintained and well-balanced machine consumes less energy and therefore emits less CO_2.

Within the MORE4Sustainability Framework, we distinguish the following focus areas within this quadrant: Asset Energy Efficiency Care, Predictive Maintenance, and High Precision Maintenance. The benchmark research shows that Asset Energy Efficiency Care has the highest impact within this quadrant (see figure 4.1).

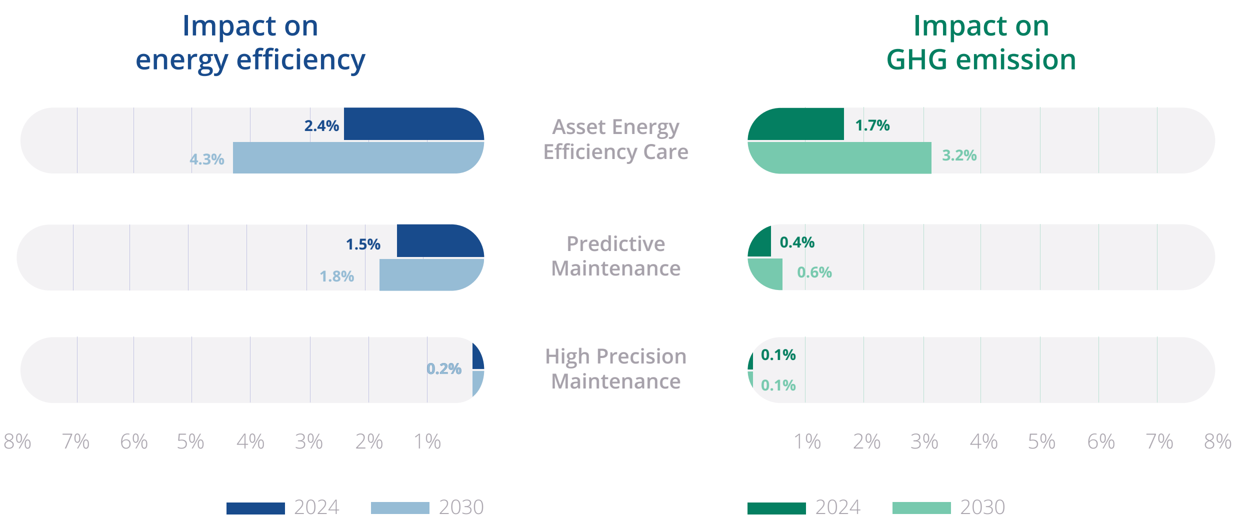


Figure 4.1 | Impact of Asset Health Optimisation.

Asset Energy Efficiency Care

Asset Energy Efficiency Care is a method derived from Operator Asset Care. It focuses on proper maintenance and alignment of machines to optimise energy efficiency, reliability, and performance. In this way, energy waste can be significantly reduced.

Within the focus area Asset Energy Efficiency Care, we distinguish six practices:

- **Regular cleaning** involves preventing energy inefficiencies by regularly cleaning machines and equipment (such as electric motors, sensors, and instruments) used in the production process.
- **Lubrication** means applying the correct type and amount of lubrication to reduce friction and wear.
- **Filter maintenance** includes inspecting clogged filters, cleaning them, and periodically replacing filters used in various equipment, machines, or systems within production processes.
- **Operator maintenance**, also known as autonomous maintenance, refers to the practice where frontline operators take responsibility for routine care, inspection, and minor maintenance of equipment and machines.
- **Routine Inspections** is about conducting frequent inspections to identify and address issues such as leaks, misalignment, or wear on equipment that may affect energy performance. These inspections can also be used to monitor facilities that impact energy efficiency, such as turning off unused equipment, adjusting thermostat settings, and switching off lights.
- **Monitor equipment settings** means ensuring optimal settings for temperature, speed, pressure, and flow rate to achieve maximum energy efficiency.

The benchmark study shows that all these activities are widely applied. The implementation rate of operator maintenance is lower, and this can be explained by the fact that not all factories have operators working directly on the production line. For example, in a chemical plant or oil refinery, the production line is typically operated from a central control room.

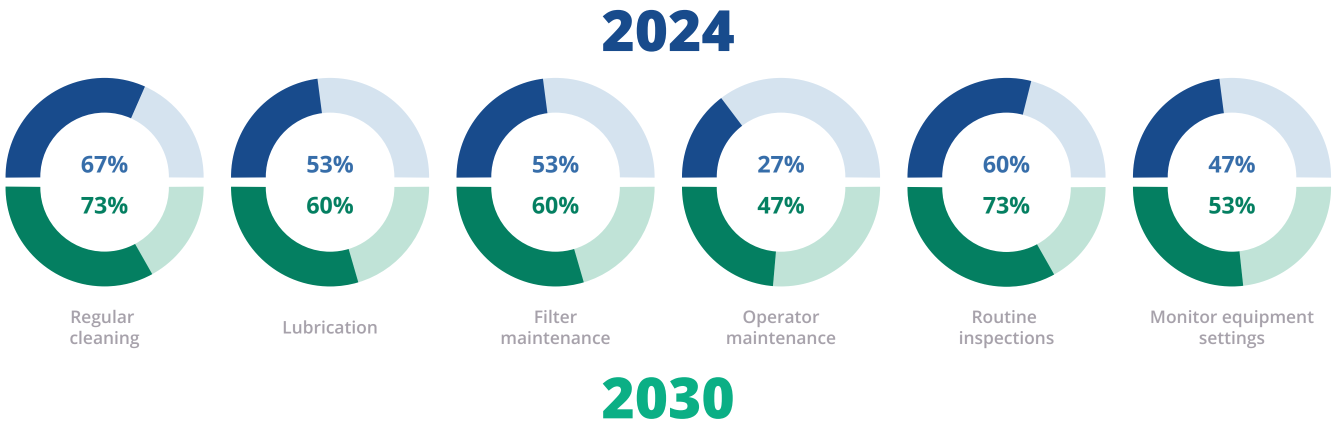


Figure 4.2 | Implementation degree of Asset Energy Efficiency Care.

Predictive Maintenance

Predictive Maintenance is an increasingly popular application that focuses on making failures predictable by using smart algorithms based on condition data, production data, maintenance data, and environmental data. This prediction based on data and measurements can be performed by human experts and/or by machine learning algorithms and artificial intelligence.

Companies applying Predictive Maintenance experience that this approach also helps optimise energy consumption. It provides insight into how machines behave, when deviations occur, and how this can be prevented.

Within Predictive Maintenance, we distinguish three variants:

- **Predictive maintenance via condition monitoring**, which involves visual inspections, use of measuring instruments, and real-time monitoring based on offline condition data (from portable devices or mounted sensors) and/or online condition data and their analysis.
- **Predictive maintenance through Integrated Data Analyses (IDA) and predictive modeling**, where more data is collected and analysed than just condition data, such as process data (from sensors and DCS, MES, or MOM systems) and environmental data to predict future behaviour, possible failures, and the remaining lifespan of equipment.
- **Prescriptive maintenance** based on data analyses, machine learning, and other artificial intelligence (AI), where we not only predict when a machine will fail but also prescribe the mitigating measure. The main feature of prescriptive maintenance is the ability to make useful recommendations based on predictive analyses, historical data, real-time data input, and advanced algorithms.

In practice, primarily variant 1 (condition monitoring) is applied. Not many companies are able to progress to integrated data analyses and prescriptive maintenance. This is also confirmed by other studies on this topic ("Digital Trends in Maintenance & Asset Management", PwC & Mainnovation, 2023).

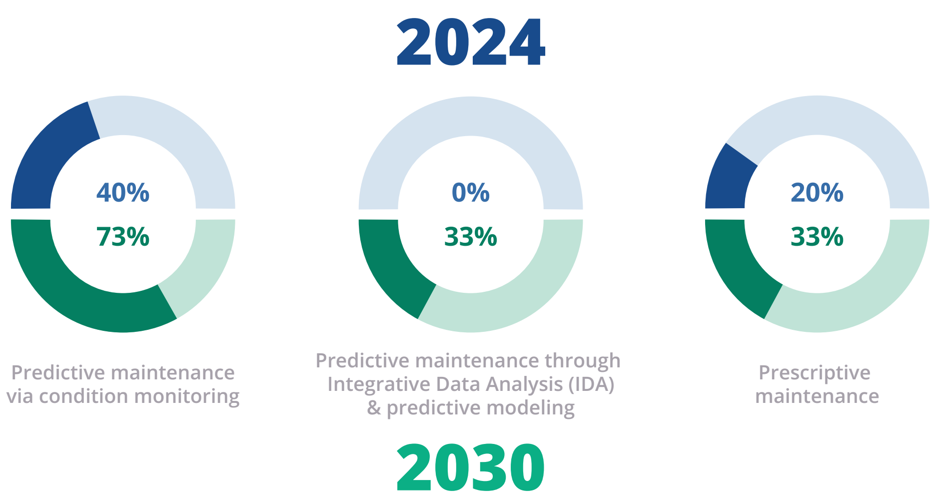
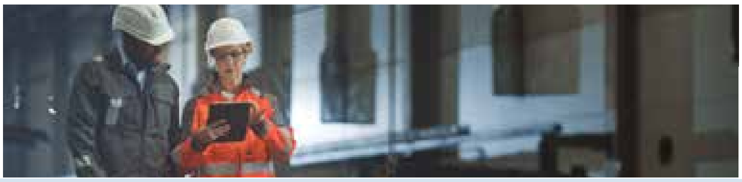


Figure 4.3 | Implementation degree of Predictive Maintenance.



Case Story

The many benefits of predictive maintenance

Sitech is a service company in the field of maintenance, engineering, turnarounds and projects. The company is located on the Chemelot site in Geleen. This industrial estate in the south of the Netherlands is home to approximately 60 chemical factories.

At the Sitech Asset Health Center the focus is on digitising the process industry. The company has shown that digitisation in manufacturing helps to improve safety, performance, reliability and energy consumption. The Sitech Asset Health Center is a scalable, Condition Based Monitoring solution, which can be implemented plant-wide at new facilities and for aging assets.

By applying predictive maintenance Sitech provides insight into how factories operate. Based on real-time monitoring and technologies such as vibration sensors, infrared cameras and ultrasonic measurements, deviations can be detected faster to prevent failures and downtime. Also unplanned flaring events can be reduced significantly because real-time monitoring alerts process engineers to potential issues early so they can prevent them from becoming an unexpected failure or serious processing inefficiency that causes a flare event.

By predicting when, for instance, a pump will fail, it enables companies to include replacement activities in the regular maintenance schedule and thereby reduce downtime. This way annual savings of around 60,000 euros can be realised just for one pump, while the sensors and model development only cost a fraction of that.

It is also possible to use a model which observes all pumps of a certain type or all heat exchangers at a site. Even though rotary pumps, for example, may have different manufacturers and different specifications, they all operate on the same physical principles. It is possible to use similar sensors and models for all rotary pumps.

The Sitech Asset Health Center and the use of predictive maintenance have saved millions, primarily by minimizing unplanned downtime and reducing energy consumption. Predictive maintenance makes it easier to understand machine behavior so that adjustments can be made to improve energy efficiency and prevent problems.

⇒ Source: www.sitech.nl and "Predictive Maintenance 4.0", PwC and Mainnovation, 2018.

High Precision Maintenance

High Precision Maintenance refers to maintenance techniques applied to machines with an emphasis on accuracy, adherence to strict tolerances, and the balancing of machines. The goal is to ensure that assets operate within optimal parameters, thereby reducing wear and tear, extending lifespan, preventing unexpected downtime, and improving the energy efficiency of the machines.

The following practices are distinguished:

- **Precision measurements** by using highly accurate measuring instruments to precisely assess the condition and performance of machines and components. Examples include laser alignment systems, coordinate measuring machines (CMMs), optical measurement equipment, and precision calipers.
- **Laser accurate alignment** means utilising alignment tools to correctly set shafts and other components at operating temperatures.
- **Accurate calibration of instruments** includes verifying and adjusting the accuracy of instruments and equipment to ensure compliance with specified standards.
- **Managing tight tolerances** is about achieving precise fits and tight tolerances, especially at operating temperatures.
- **Quality assurance** means implementing strict quality control and assurance processes (inspections, tests, and verifications) to verify the accuracy and reliability of maintenance activities and confirm that equipment meets quality standards and specifications.
- **Clear maintenance instructions** means ensuring that procedures and work instructions are unambiguous and easily accessible to the appropriate personnel, enabling them to perform highly precise adjustments to critical components.

High Precision Maintenance is a relatively new application that still has few followers. Nevertheless, the benchmark study shows that sub-elements are indeed being put into practice. Notable is the growing popularity of laser alignment.

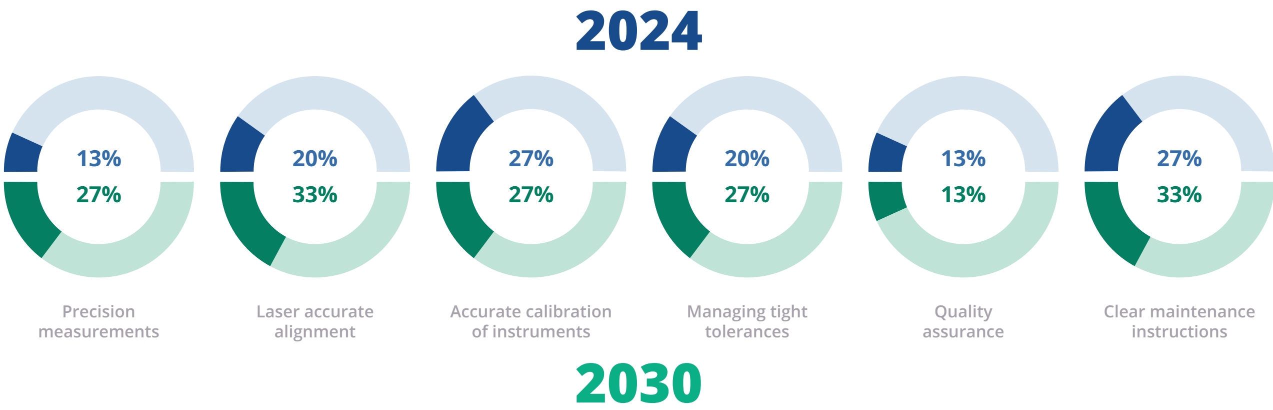
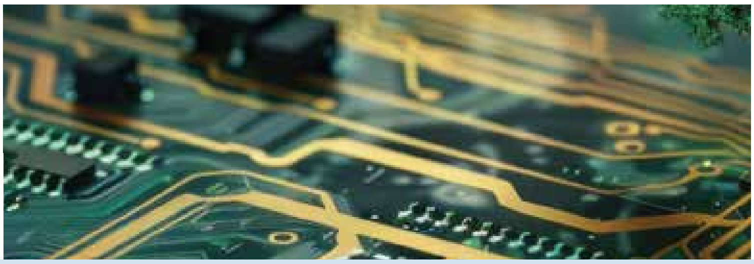


Figure 4.4 | Implementation degree of High Precision Maintenance.



Case Story

High Precision Maintenance demonstrates significant benefits

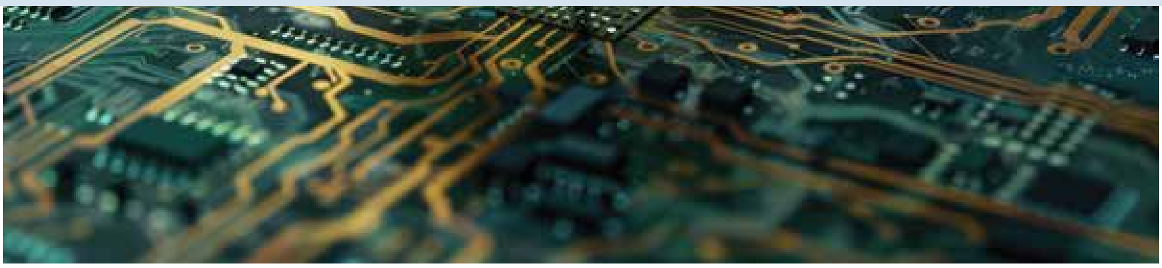
High Precision Maintenance (HPM) is a term introduced by **Intel**. It is a comprehensive approach to equipment maintenance aimed at enhancing manufacturing efficiency and reducing operational costs. It includes technologies like vibration analysis, infrared scans, laser alignments, precision balancing of rotating equipment, time-domain reflectometry, motor-current signature analysis, and electrical systems voltage waveform analysis. These methods are used to detect equipment issues in an early stage, enabling proactive maintenance and minimising unexpected downtime.

Also, HPM helps to monitor and maintain equipment at peak efficiency, ensuring that systems are running at optimal energy consumption levels. When equipment such as motors, HVAC systems, or machinery is maintained for maximum efficiency, the energy required to run those systems is minimised, directly contributing to lower energy usage.

The implementation of HPM has demonstrated significant benefits across various industries. For instance, at a chemical plant that adopted an HPM program, emergency work dropped from 24 percent to 4 percent and the On-Stream Factor (the time an operating unit actually produces product at a scheduled rate versus the time the unit has been scheduled to produce product) increased to nearly 99 percent. This improvement in OSF translates to substantial financial gains; for a plant with an annual profit of over €90 million, each 1% increase in OSF corresponds to roughly an additional €1 million in profit.

High Precision Maintenance helps drive energy efficiency improvements and GHG emission reductions by minimising energy waste, increasing equipment lifespan, ensuring efficient operation, and leveraging real-time data for optimal resource management. These benefits are critical in reducing the environmental impact of energy-intensive processes.

⇒ Source: www.industryweek.com



Chapter 5 *Energy Consumption Optimisation*

In the first two quadrants of the MORE4Sustainability Framework, the focus is on replacing polluting machines by sustainable ones and on optimally maintaining and aligning these machines. This already leads to higher energy efficiency. Additionally, measures can be taken to further reduce the energy consumption of these machines. This is referred to as Energy Consumption Optimisation.

Energy Consumption Optimisation is aimed at maximising energy efficiency and minimising energy waste in various systems, processes, and activities. The goal is to achieve the desired performance level or production output with as little energy consumption as possible.

Within Energy Consumption Optimisation, we distinguish the following three focus areas: Thermal Energy Loss Prevention, Thermal Energy Recovery & Reuse, and Electrical Energy Optimisation. The benchmark study shows that Electrical Energy Optimisation has the highest impact on improving energy efficiency. Because of the fact that this focus area targets electrical energy, its impact on GHG emissions is limited.

In contrast, Thermal Energy Recovery & Reuse has a significant impact on GHG Emission Reduction, according to the study. This can be explained by the fact that heat generation is often still carried out using fossil fuels via steam boilers or industrial burners on-site.

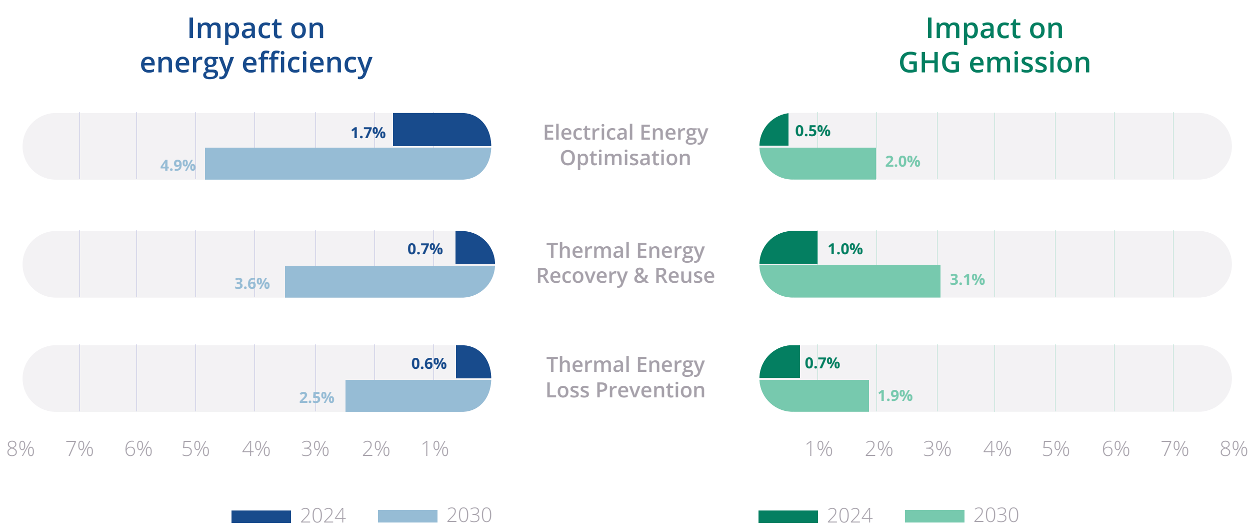


Figure 5.1 | Impact of Energy Consumption Optimisation.

Thermal Energy Loss Prevention

Thermal Energy Loss Prevention focuses on minimising or eliminating unnecessary heat loss from industrial processes, equipment, or buildings. The first step is identifying where heat loss occurs. This can be done by placing temperature sensors on machines or using infrared thermography, which creates thermal images of a machine.

Once the locations of heat loss are known, targeted measures can be taken to reduce this, such as insulation. Also, quickly detecting energy losses (caused by leaks) through sensors and infrared images enables rapid repairs, preventing the loss of large amounts of energy.

Thermal Energy Loss Prevention is about the following practices:

- **Insulation** of equipment, pipes, ducts, tanks and building envelopes properly to reduce heat transfer and minimise thermal losses. Insulating materials such as foam, fibreglass, mineral wool and reflective coatings help maintain temperature stability and prevent energy wastage.
- **Thermal imaging and infrared thermography** are used to detect thermal energy leaks by capturing thermal images of surfaces and identifying temperature variations. Hotspots, cold spots and areas of thermal bridges indicate possible locations of heat loss that require further investigation.
- **Temperature sensors** are used to measure surface temperatures and detect deviations from expected values, indicating possible heat leakage points.

Benchmark results show that the application of insulation is not new. By 2024, nearly 70% of companies had fully implemented this measure.

We also see that the introduction of temperature sensors is growing and is stimulated by the fact that these types of sensors are being fitted as standard on more and more equipment. Through smart integrations with energy management systems, deviations can be easily detected.

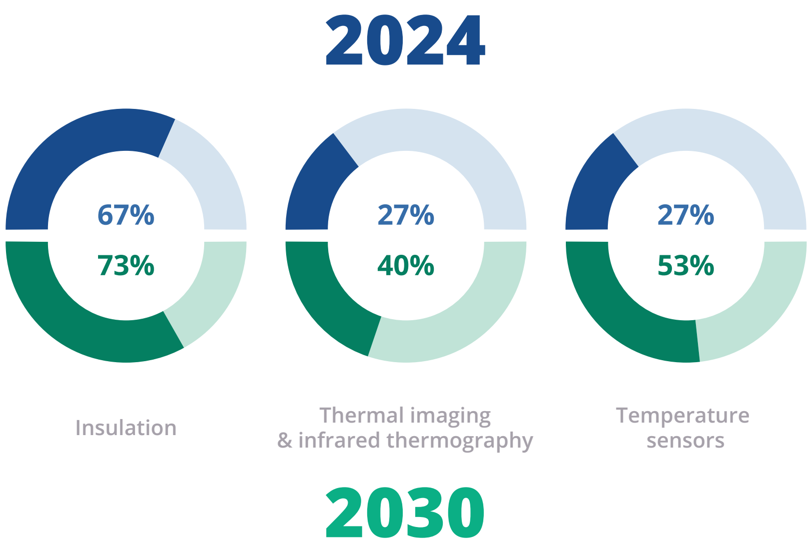


Figure 5.2 | Implementation degree of Thermal Energy Loss Prevention.

Thermal Energy Recovery & Reuse

In addition to machine insulation, Thermal Energy Recovery & Reuse can be applied. This focus area concerns capturing waste heat generated during industrial processes, HVAC systems, or other energy-intensive operations, and then using it to meet heating, cooling, or other energy needs within the same facility or in nearby applications.

Within this focus area, we distinguish the following practices:

- **Heat recovery systems** such as heat exchangers, to capture waste heat from exhaust gases, process streams, or equipment cooling systems and use it for heating, preheating, or other industrial processes. Combined Heat and Power (CHP) systems can be used to simultaneously generate electricity and recover waste heat for heating or cooling purposes.
- **District heating and cooling networks** can be set up to exchange waste heat or cold with nearby industrial facilities, commercial buildings, or residential areas that need heating or cooling (see the Stora Enso and Volvo Cars case story "Use residual heat as a renewable energy source").

- **Integration of industrial processes** to use waste heat from one process within the facility as a heat source for another process, for example by implementing process cascade or heat cascading strategies.
- **Cogeneration systems** involve implementing combined heat and power (CHP) setups to simultaneously generate electricity and recover waste heat for heating or cooling purposes.
- **Thermal storage systems** can be implemented to store excess heat during periods of low demand and release it when needed. This also includes the installation of heat pump systems to upgrade waste heat to higher temperatures suitable for heating or industrial processes.

The benchmark study shows that the use of heat recovery systems is the most applied practice within this focus area.

The heat recovery systems are relatively inexpensive compared to the other options within this focus area. Integration with other industrial processes of other companies is often already included in the design phase of a factory. This option, and that of connecting to district heating, only become interesting when a (commercial) opportunity arises to realise this later. From a sustainability perspective, it is therefore difficult to deploy this as a planned measure.

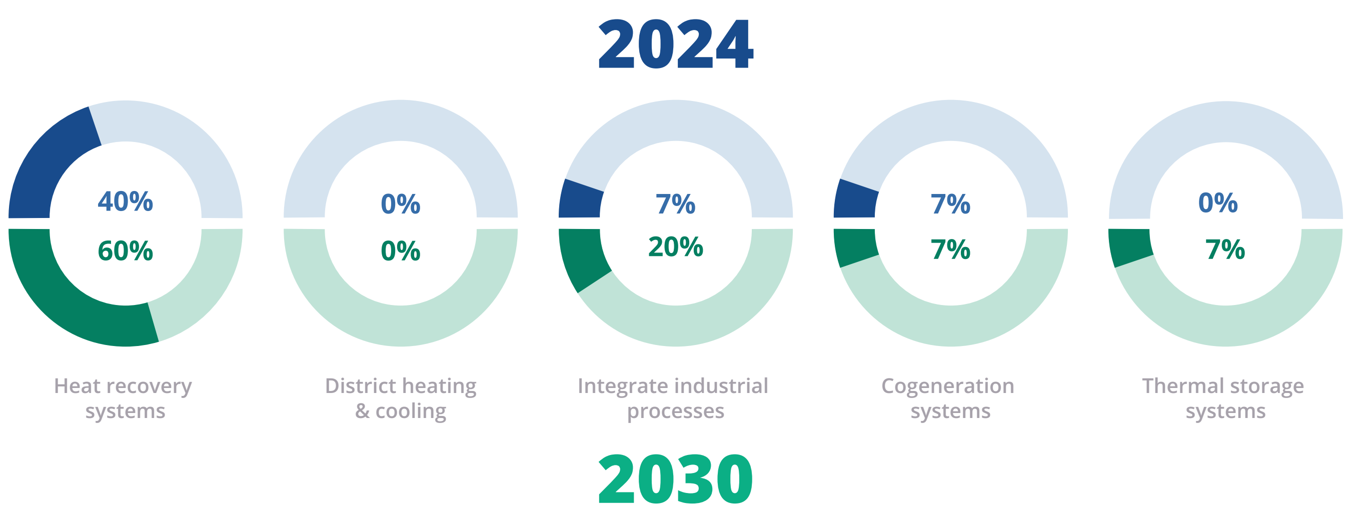


Figure 5.3 | Implementation degree of Thermal Energy Recovery & Reuse.

Case Story

Use residual heat as a renewable energy source

Stora Enso, supplier of sustainable packaging and materials, and **Volvo Cars** Ghent started a collaboration a few years ago for the construction of an underground heating network with the aim of exchanging residual heat. By connecting the Stora Enso site in Evergem to the Volvo Cars Ghent, the recovered residual heat from biomass could be used by Volvo Cars to dry cars in the spray and paint department.

The Stora Enso factory annually produces 550,000 tonnes of paper for newspapers and magazines, based on wastepaper. The factory has two high-performance bio combined heat and power (CHP) power plants, which not only supply all the process steam required, but also provide more than 70% of its electricity needs. Stora Enso wanted to make the excess residual heat available to Volvo Cars Ghent via an underground heating network (length 4 km). This allowed Volvo to efficiently use the residual heat for their production processes and significantly reduce fossil energy consumption.

The heat network makes smart use of two Stora Enso bio-CHP plants, which convert internal sludge and external biomass into electricity and process heat. This generated energy heats up water to 135°C, which is then transported to Volvo Cars Gent to reach the desired temperature in the buildings and spray booths. The cooled water returns to Stora Enso, where it is reheated.

The (green) energy supplied has a capacity of 25 MW, the equivalent of the energy needs of 5,000 homes. Antea Group was responsible for the technical design, the permitting process and selecting the best contractor meeting the specified requirements and quality standards.

⇒ Source: www.media.volvocars.com/global/en-gb/media/pressreleases/

Electrical Energy Optimisation

The final focus area within this quadrant (Energy Consumption Optimisation) is Electrical Energy Optimisation. This involves maximising the efficiency of electricity consumption and minimising the GHG emissions associated with electricity generation. This reduces electricity consumption, achieves significant savings, and lowers operating costs.

Common practices within this focus area are:

- **HVAC optimisation** means optimising heating, ventilation, and air conditioning systems to reduce energy consumption. Possibilities include temperature reductions, optimising airflow, and using programmable thermostats to create comfortable indoor temperatures while minimising energy use.
- **Lighting upgrades** refers to replacing traditional incandescent and fluorescent lamps with energy-efficient lighting systems that consume less energy, last longer, and produce less heat.
- **Optimising motors and drives** is about improving efficiency and reducing energy waste. Using variable frequency drives to control motor speed and match power to demand reduces energy consumption during partial load. This practice focuses only on electrically powered devices that have been upgraded to higher electrical energy efficiency. Replacing non-electric devices with electric ones falls under the topic of Plant Electrification in the first quadrant.
- **Load balancing** means adjusting the distribution of power across different systems or components to prevent overload and ensure each part operates optimally.
- **Power factor correction** is about improving the power factor in an electrical system to reduce the amount of inactive and useless power.

The benchmark results show that only HVAC optimisation is still expected to see reasonable growth among the early adopters. Upgrading lighting and optimising motors and drives are implemented by the majority and thus seen as important options for Electrical Energy Optimisation.

Load balancing and power factor correction, in particular, lag behind. This can be explained by the fact that these measures are still relatively unknown and have a considerable degree of complexity. Moreover, old systems are not designed for active load balancing, for example.

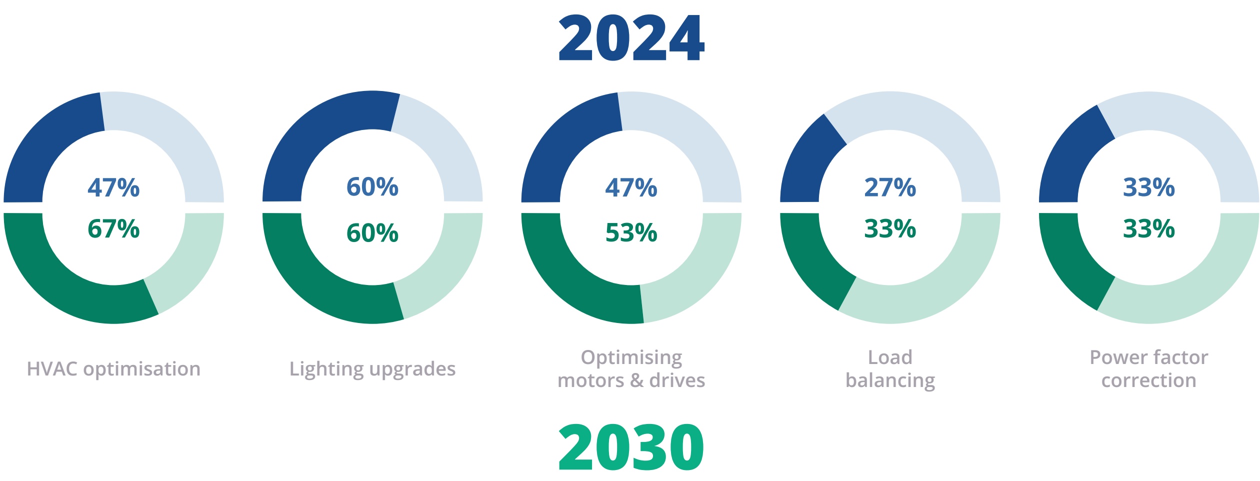


Figure 5.4 | Implementation degree of Electrical Energy Optimisation.

Case Story

Thermal vapor recompressor provides significant energy savings

Royal Cosun (Netherlands) develops food, food ingredients, animal feed, biobased ingredients and green energy. Their goal is to be completely CO_2 neutral by 2050.

One of the subsidiaries is Cosun Beet Company. In 2020, when the name Suiker Unie was still used, Royal Cosun installed a thermal vapour recompressor at the site in Dinteloord. How does this innovation contribute to CO_2 neutrality?

The site in Dinteloord processes around a thousand trucks of sugar beets every day from September to January. The sugar juice is extracted from the beet using diffusion. This juice is purified, then evaporated into thick juice and then crystallised into sugar. This evaporation process is done with the energy from steam. The process consists of several 'stages' and the steam is reused at each stage. In 2016, a highly efficient seven-stage evaporation process was installed, which allowed Suiker Unie to save 14 percent on the energy demand of the process. But despite of this significant saving, Suiker Unie still lost a considerable amount of residual heat.

After extensive research into energy saving and energy loss, a thermal vapor recompressor was installed, which reduced the loss to almost zero.

The site is now at around 60 percent CO_2 reduction compared to 1990. The aim is to achieve a 75 percent CO_2 reduction in 2030 and to be completely climate neutral in 2050. To this end, Cosun is conducting a lot of research into CO_2 reduction measures.

The thermal vapour recompressor cost around €2.5 million, but the project was eligible for the DEI+ subsidy. And because the recompressor saves a lot of energy, it is also eligible for the Energy Investment Deduction (EIA).

⇒ Source: www.nieuweoogst.nl/nieuws/

Chapter 6 *GHG Emission Optimisation*

In the previous three quadrants we primarily focused on energy efficiency. By improving energy efficiency, the majority of GHG reduction is already achieved because lower and greener energy consumption automatically leads to a decrease in GHG emissions. In this fourth quadrant we will discuss how we can reduce GHG Emissions on top of that.

Within the MORE4Sustainability Framework, we distinguish the following focus areas in this quadrant: Fugitive Emission Prevention, GHG Capturing & Reuse, and Renewable Energy Generation.

In contrast, Thermal Energy Recovery & Reuse has a significant impact on GHG Emission Reduction, according to the study. This can be explained by the fact that heat generation is often still carried out using fossil fuels via steam boilers or industrial burners on-site.

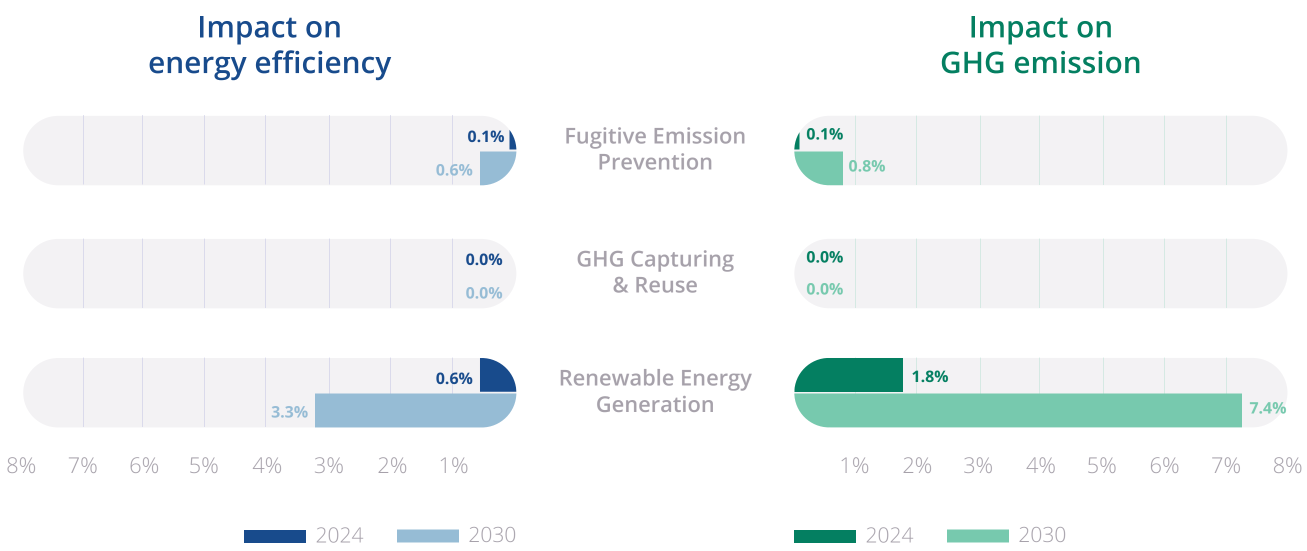


Figure 6.1 | Impact of GHG Emission Optimisation.

Fugitive Emission Prevention

The first measure to limit GHG emissions is Fugitive Emission Prevention. This focus area refers to measures implemented to minimise or eliminate the release of fugitive emissions (greenhouse gases other than CO_2) into the atmosphere. These fugitive emissions are unintended releases of gases, vapors, or particles from industrial equipment, processes, or facilities that occur outside controlled emission points such as chimneys or vents.

By implementing measures, industries can minimise their environmental impact, protect human health, and comply with legal requirements.

Within this focus area, we distinguish the following practices:

- **Leak detection and repair (LDAR)** involves implementing programs to identify sources of fugitive emissions in equipment and piping systems and repair them immediately. This can be done using online and offline leak detection instruments, such as gas detectors, infrared cameras, or ultrasonic leak detectors. (see the Bouter Cheese case story on the next page: “Detecting air leaks yourself proves to be very beneficial”)
- **Sealing and repair** means ensuring that seals, gaskets, and other components are properly installed, maintained, and replaced when necessary to prevent leaks and emissions. This may involve using high-quality sealing materials, employing proper installation techniques, and immediately repairing or replacing worn or damaged components. Proper training of technicians is a must for this.
- **Emission control technologies**, such as vapor recovery units, flares, thermal oxidizers, and scrubbers, can be used to capture and destroy volatile emissions before they enter the atmosphere. In certain sectors these systems may be a requirement.

Case Story

Detecting air leaks yourself proves to be very beneficial

Until recently, Peter Spiegelenberg, Head of TD and Engineering at **Bouter Cheese**, hired an external contractor to execute air leak inspections. But recently, in cooperation with another Bouter Cheese plant, he purchased his own acoustic camera. "By being much more on top of things, we save more electricity."

The purchased acoustic imaging camera detects and reduces leaks, thereby cutting costs associated with compressed air and gas leaks. It also identifies mechanical faults, such as bearing issues, facilitating preventative maintenance.

Spiegelenberg: "The investment for this camera was approximately € 16,000, but this was quickly recouped. The external contractor charges approximately € 5,000 for their annual services. In addition, it means saving electricity."

This is evident from the following calculation example: 1,000 liters of air costs 0.11 kWh and 0.03 cents. A medium-sized leak on an air hose reel causes a leakage of 60 liters per minute (60 LPM) and therefore costs 2,290 kWh/year and € 618 per year. "And yes, we have already detected several small leaks. Also, by carrying out this more frequently, which is possible because you have the technology in-house, you can detect leaks more quickly," says Spiegelenberg, thus concluding: "Proper monitoring of air leaks is therefore interesting for both energy efficiency and the environment."

⇒ Source: www.boutergroup.com

The benchmark study shows that Leak Detection and Repair (LDAR) is the most commonly used practice within this focus area. The low impact of LDAR on sustainability can be explained by the fact that it is primarily done to comply with environmental laws & legislations.

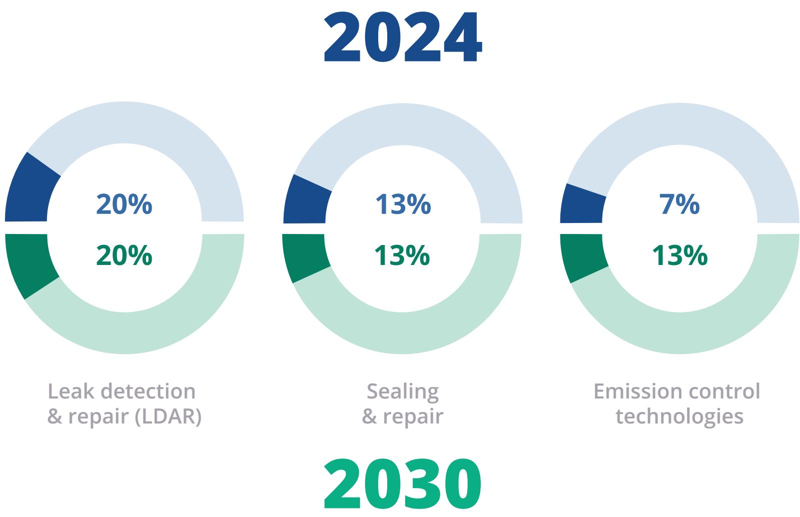


Figure 6.2 | Implementation degree of Fugitive Emission Prevention.

GHG Capturing & Reuse

Another method to reduce GHG emissions is GHG Capturing & Reuse. This involves, on the one hand, capturing carbon dioxide (CO_2) and other greenhouse gases emitted by industrial processes or electricity generation facilities, and on the other hand, using or reusing these captured gases in various applications to reduce total emissions.

Within this focus area, we distinguish the following four practices:

- **Capture technologies** to capture CO_2 and other greenhouse gases emitted by industrial sources. Commonly used capture technologies include post-combustion capture, pre-combustion capture, and oxy-fuel combustion.
- **Transport and storage** involves transporting captured greenhouse gases to storage locations where they can be safely stored underground or used in other applications. An example of this is Carbon Capture and Storage, where captured CO_2 is injected into geological formations, such as depleted oil and gas reservoirs or saline aquifers, for long-term storage.
- **Use and conversion** of captured greenhouse gases includes using CO_2 for enhanced oil recovery, the production of synthetic fuels and chemicals, and the use of CO_2 in industrial processes such as carbonation of concrete or the production of plastics.
- **Biological conversion** means employing biological processes, such as algae cultivation or microbial conversion, to capture CO_2 and convert it into biomass or other valuable products. For example, algae-based systems can capture CO_2 from industrial emissions and convert it into biomass, which can then be used as a raw material.

The benchmark study shows that these applications are currently being used to a very limited extent. Nevertheless, the media pays a lot of attention to the potential of GHG Capturing & Reuse (see INEOS case story on the next page). Time will tell whether the industry will truly embrace this application.

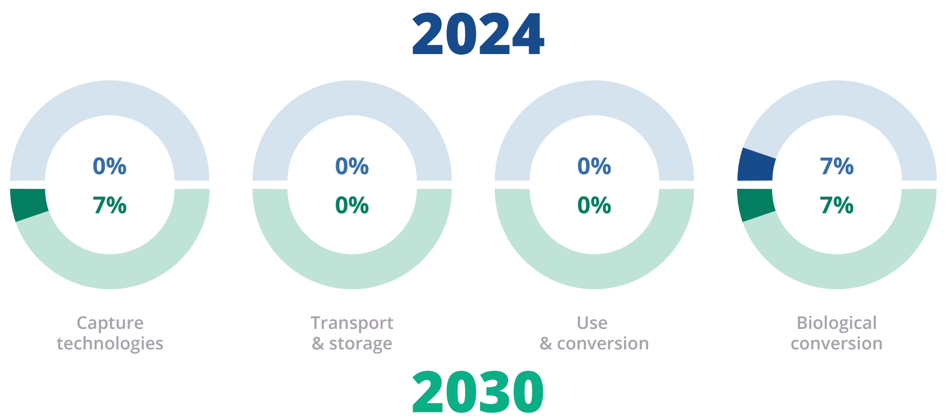


Figure 6.3 | Implementation degree of GHG Capturing and Reuse.

Case Story

Carbon capturing in the North Sea

In March 2023 **INEOS** achieved the world's first cross border off-shore CO_2 storage initiative. The successful trial saw CO_2, captured from INEOS Oxide's plant in Belgium and shipped 500 miles by to their Nini offshore oil platform in the Danish North Sea. With this project INEOS has shown that CO_2 can be safely captured, transported and injected into retired oil and gas wells under the seabed.

Project Greensand, as it is known due to the type of sandstone under the seabed, was set up purely to protect the environment.

The liquefied gas was injected into a retired oil reservoir 2 km under the seabed. The project proved that carbon capture and storage is a viable way to permanently store CO_2 emissions under the North Sea. Carbon capture and storage is seen as critically important to help decarbonise the world's energy and tackle climate change. Instead of dismantling oil rigs, they can be repurposed.

The plan now – following this successful trial – is to start operating commercially in 2025. Once fully operational, it should be able to store up to eight million tonnes of CO_2 every year.

⇒ Source: www.ineos.com/inch-magazine/articles/

Case Story

Capturing industrial CO_2 and reusing it to grow flowers

There are several ways in which the re-use of CO_2 could result in displacement of fossil fuels. A relatively simple one is using CO_2 in greenhouses in the greenhouse horticulture sector where it displaces burned natural gas for the production of the CO_2 in greenhouse applications. This option is already applied at a relatively large scale in the Netherlands.

OCAP is a CO_2 network for the Dutch greenhouses. **OCAP** means Organic CO_2 for Assimilation by Plants. The CO_2 is captured in industrial processes of Shell Pernis and Alco (both companies are located in Europoort Rotterdam) to help reduce carbon emissions by greenhouses north of the port (the area is called Westland). The system is operated by OCAP and this is a subsidiary of Linde Gas. As early as 2005, the first CO_2 was supplied to horticulturists in 'the Westland'.

This CO_2 is produced at Shell during the production of H_2 in an oil gasifier, and during the production of bio-ethanol at Alco. In 2020, Alco's capacity was increased with the construction and commissioning of a second compressor. OCAP supplies this CO_2 via a pipeline with an extensive distribution network. This enables greenhouses to save about 115 million cubic metres of natural gas a year, which would otherwise be used in the greenhouses to produce the CO_2. The greenhouses annual CO_2 emissions are reduced by about 205 ktpa.

OCAP now supplies hundreds of kilotons of CO_2 per year to more than 600 greenhouse growers. Greenhouse horticulture can and wants to switch to sustainable energy, but this is only possible if there is sufficient CO_2 available. OCAP is therefore constantly looking for new sources.

⇒ Source: www.ocap.nl

Renewable Energy Generation

The last focus area within this quadrant, Renewable Energy Generation, is indeed already widely applied. This focus area refers to the process of on-site producing electricity or other forms of energy by using renewable energy sources that are naturally replenished and sustainable in the long term (including sunlight, wind, biomass, and geothermal heat). The goal of on-site renewable energy generation is to reduce greenhouse gas emissions (Scope 1), but it may also lead to lower consumption of purchased electricity and thus impact Scope 2.

We see the following practices in this field:

- **Solar energy systems** where electrical and/or thermal energy is generated by capturing sunlight using photovoltaic (PV) panels or concentrated solar power (CSP) systems. PV panels convert sunlight directly into electricity, while CSP systems use mirrors or lenses to concentrate sunlight onto a receiver, which then converts it into heat (thermal energy). This heat can be used to generate electricity (electrical energy).
- **Wind energy systems** to harness the kinetic energy of the wind to rotate turbines, which then convert the wind's energy into electricity.
- **Biomass energy systems** that produce heat or electricity by burning organic materials such as wood, agricultural residues, or waste biomass. Biomass can also be converted into biofuels such as ethanol and biodiesel for use in transportation or heating.
- **Geothermal energy systems** to generate geothermal energy by harnessing heat from the earth's interior. This is usually done using geothermal heat pumps to heat and cool buildings.

The benchmark study shows that there has been a particular focus on building own green energy generation, and that ambitions are high towards 2030, especially in wind and solar energy.

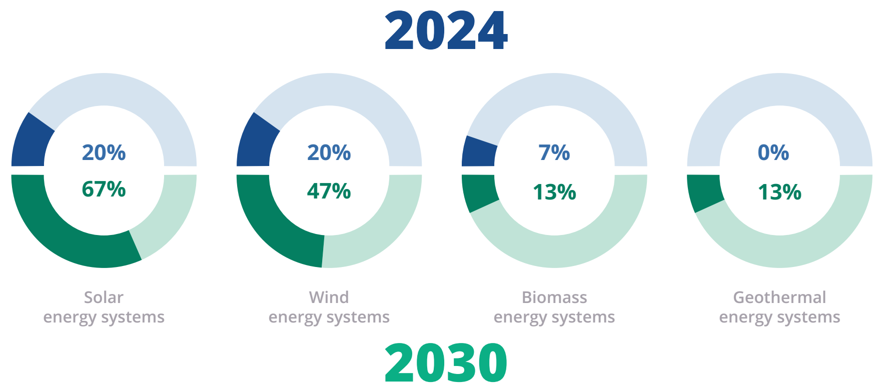
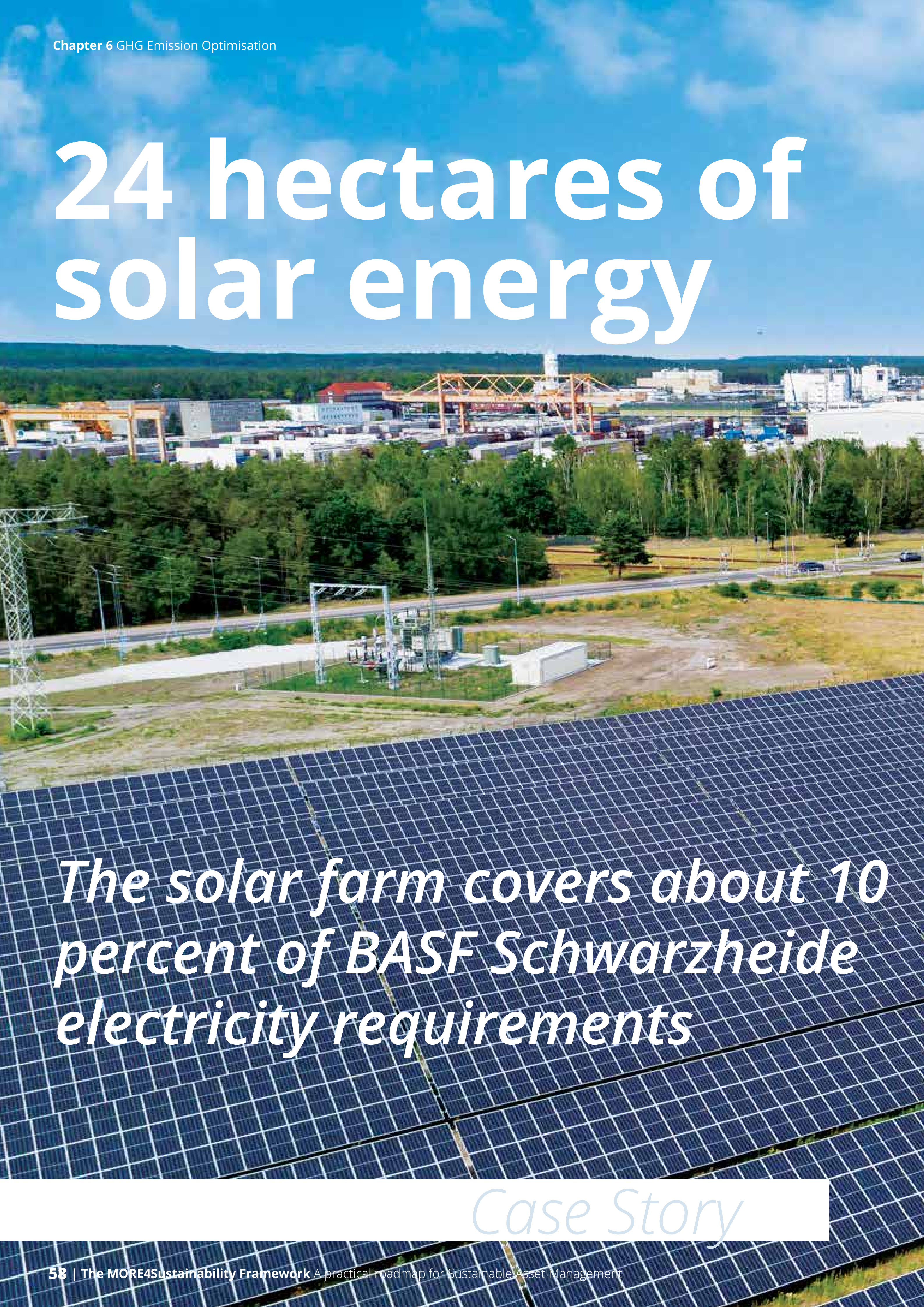


Figure 6.4 | Implementation degree of Renewable Energy Generation.



24 hectares of solar energy

The solar farm covers about 10 percent of BASF Schwarzheide electricity requirements

Case Story

To reduce its carbon footprint, BASF Schwarzheide GmbH is focusing on efficient production processes, innovative circular economy, and a sustainable energy supply. In August 2022, BASF Schwarzheide and envia Mitteldeutsche Energie AG (enviaM) commissioned the first joint solar farm. On an area of 24 hectares a solar farm with around 52,000 photovoltaic modules was built. The goal is to provide green electricity to BASF's production site in Lusatia (Germany).

As a chemical company, BASF Schwarzheide is making an important contribution to increase sustainability by promoting the integration of renewable energies, making its production energy-efficient, and aligning its operations with circular economy principle. Its product range includes polyurethane base products and systems, crop protection products, waterborne basecoats, engineering plastics, foams, performance chemicals, and battery materials.

10 Percent

In a timeframe of six months the solar farm and a transformer station were build. With a total installed capacity of 24 megawatts peak (MWp) and an expected electricity production of 25 gigawatt hours (GWh) per year, the plant is the first major solar power plant to be implemented by BASF together with a partner. The enviaM-group is a regional energy service provider in eastern Germany. The group supplies almost 1.3 million customers with electricity, gas, heating and energy services.

The solar farm aims to cover about 10 percent of the electricity requirements of the BASF production site on an annual average. The total investment for the solar farm and the adjoining transformer station amounts to around 13 million euros. The project was implemented without public funding.

Compensation

Extensive compensatory measures were implemented on the area used for the transformer station and the solar farm, such as the creation of a dry and rough grassland and a wildflower strip as well as the installation of nesting aids for breeding birds. In the course of the construction measures, an old rainwater drainage system was also rebuilt.

Development of solar energy

After completion of the project Minister of Economics and Energy Prof. Dr.-Ing. Jörg Steinbach remarked: "Solar energy has developed rapidly in recent years and is making an increasingly important contribution to the energy supply. If we want to achieve our energy and climate protection goals, the increased expansion of renewable energies is essential. We need clean electricity generated regionally from renewable energies. The solar farm in Schwarzheide shows that electricity from PV ground-mounted systems has become competitive and can also be accomplished without subsidies."

CO_2-neutral

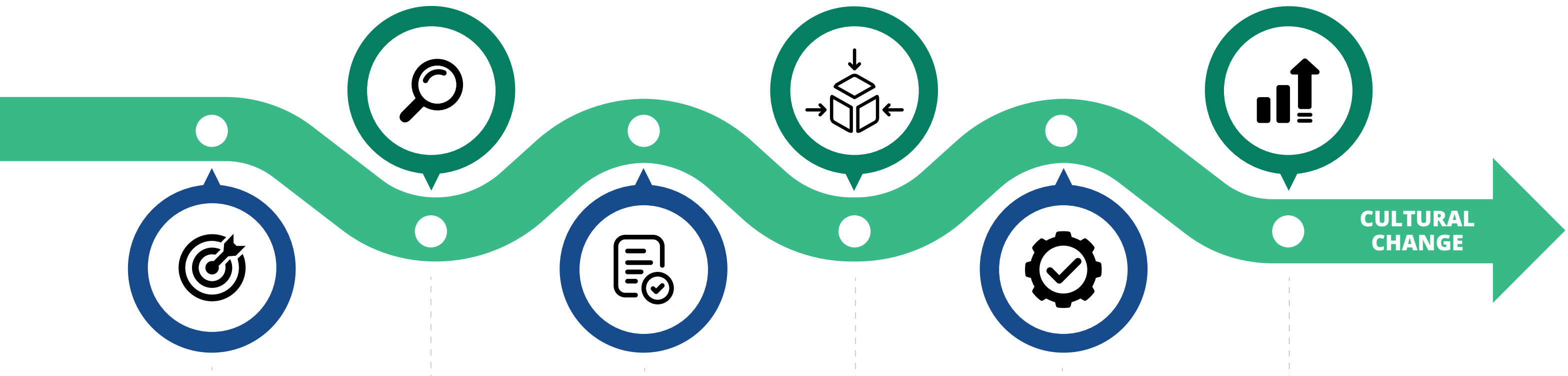
BASF Schwarzheide GmbH is aiming to become one of BASF's first CO_2-neutral production sites. Access to renewable energy at competitive prices is a basic prerequisite for this. The commissioning of the joint solar farm is a first, big step in this direction, which will be followed by others. This solution aligns perfectly with long-term sustainability goals and ensures strong economic returns, making it the ideal choice for the company's energy transition.

⇒ Source: www.basf.com

Chapter 7 *Implementation Roadmap*

Now that all elements of the MORE4Sustainability Framework have been explained and it is clear which focus areas and practices make the difference, this chapter offers a practical step-by-step plan to apply Sustainable Asset Management.

For this purpose, the Implementation Roadmap, can be used. This roadmap consists of six steps (see figure 7.1) and those will be further explained on the following pages.



1 DEFINE STRATEGY & TARGETS

- Understand corporate sustainability strategy & targets
- Translate corporate strategy to AM domain
- Define preliminary targets on EE and GHG
- Add sustainability chapter to SAMP
- Align preliminary targets with other AM targets

2 PERFORM SELF-SCAN & SET ACTIONS

- Analyse current state
- Identify improvement areas
- Set action plan and impact on EE and GHG
- Determine required investments and costs
- Update SAMP and targets on EE and GHG

3 CREATE BUSINESS CASE & GET APPROVAL

- Analyse energy costs
- Analyse GHG emission costs
- Calculate benefits on EE and GHG
- Calculate business case (ROI, NPV, PBP)
- Get approval for action plan

4 BUILD FOUNDATION & TACTICAL ENABLERS

- Select appropriate (ISO) standards
- Implement/ optimise work processes
- Implement/optimise IT tools
- Train staff
- Implement AI if applicable

5 EXECUTE & MONITOR ACTION PLAN

- Implement Asset Portfolio Optimisation actions
- Implement Asset Health Optimisation actions
- Implement Energy Consumption Optimisation actions
- Implement GHG Emission Optimisation actions
- Monitor action plan

6 EVALUATE & IMPROVE STRATEGY

- Evaluate progress and costs action plan
- Evaluate targets on EE and GHG
- Improve strategy and update action plan and business case

Figure 7.1 | The MORE4Sustainability Implementation Roadmap.

Step 1: Define Strategy & Targets

The first step in the Implementation Roadmap is to develop a Sustainable Asset Management Strategy. This step begins with translating the corporate sustainability strategy into the Asset Management domain. The primary question that needs to be answered is: to what extent can the Maintenance and Asset Management organisation contribute to the company's objectives in terms of energy efficiency and GHG emissions?

The answer to this question is translated into preliminary targets and documented in a separate Sustainability chapter in the Strategic Asset Management Plan (SAMP). The SAMP contains all targets of the Maintenance and Asset Management organisation related to technical availability, reliability, safety, costs, and lifespan, and describes how these targets should be achieved. By aligning the Sustainable Asset Management targets with the other targets within the SAMP, it is ensured that other stakeholders (Production, Finance, Safety & Health, Engineering) are not unexpectedly affected.

Step 2: Perform Self Scan & Set Actions

The second step within the Implementation Roadmap is to create an action plan. This involves the actions that need to be carried out to meet targets on Energy Efficiency Improvement and GHG Emission Reduction.

For this purpose, the MORE4Sustainability Self Scan has been developed. Based on this Self Scan, companies can analyse their current situation and identify areas for improvement.

The Self Scan is built around the twelve focus areas of the MORE4Sustainability Framework and inventories the current implementation level of the underlying practices (see figure 7.2). By comparing the current implementation level and ambition for 2030 with the implementation level of the early adopters, it becomes clear where the potential for improvement lies. To utilise this potential, actions must be identified. In the Self Scan, these actions are recorded and budgeted: what investment is needed and what happens to the annual costs?

Download the MORE4Sustainability Self Scan by scanning this **QR code** or by using the **url** below.

⇒ **https://bit.ly/M4Sdownloads**

	% Early adaptors with full implementation	Current Implementation Level	Target Implementation Level 2030	Description of action	Required Investment (€)	Additional annual costs (€)	Energy Efficiency Improvement 2030	GHG Emission Improvement 2030
1.1 Plant Electrification							Early Adaptors = 1,5%	Early Adaptors = 2,0%
1.1.1 Pumps	33%	0. Not implemented	1. Pilot implementation					
1.1.2 Compressors	40%	2. Roll out	3. Fully implemented					
1.1.3 Heating elements	40%	0. Not implemented	3. Fully implemented					
1.1.4 Vehicles and forklifts	53%	3. Fully implemented	3. Fully implemented					
1.1.5 Other	0%	1. Pilot implementation	2. Roll out					
1.2 Sustainable Asset Replacement							Early Adaptors = 5,3%	Early Adaptors = 4,9%
1.2.1 Led Lighting	67%	1. Pilot implementation	3. Fully implemented	Replacement of all lighting by LED	100.000			
1.2.2 Smart and adaptive lighting	47%	1. Pilot implementation	2. Roll out					
1.2.3 High-efficiency HVAC	33%	1. Pilot implementation	3. Fully implemented					
1.2.4 High-efficiency motors and drives	60%	0. Not implemented	2. Roll out	Replacement of 10 motors	300.000		1,0%	1,0%
1.2.5 Life extension, refurbishment and overhaul	53%	0. Not implemented	0. Not implemented					
1.2.6 Circularity for sustainable replacement	40%	0. Not implemented	0. Not implemented					
1.2.7 Other	0%	0. Not implemented	0. Not implemented					
1.3 Production Process Reengineering							Early Adaptors = 3,0%	Early Adaptors = 2,1%
1.3.1 Process optimization and redesign	53%	0. Not implemented	0. Not implemented					
1.3.2 Product conversion	27%	0. Not implemented	0. Not implemented					
1.3.3 (Partial) plant closure	7%	1. Pilot implementation	3. Fully implemented					
1.3.4 Building (a partial) new factory	27%	1. Pilot implementation	2. Roll out					
1.3.5 Circularity from process reengineering	13%	1. Pilot implementation	3. Fully implemented					
1.3.6 Other	0%	0. Not implemented	2. Roll out					
2.1 Asset Energy Efficiency Care							Early Adaptors = 4,3%	Early Adaptors = 3,2%
2.1.1 Regular cleaning	73%	3. Fully implemented	3. Fully implemented					
2.1.2 Lubrication	60%	1. Pilot implementation	3. Fully implemented	New lubrication service of supplier		20.000		
2.1.3 Filter maintenance	60%	3. Fully implemented	3. Fully implemented					
2.1.4 Operator maintenance	47%	0. Not implemented	0. Not implemented				1,0%	1,0%
2.1.5 Routine inspections	73%	3. Fully implemented	3. Fully implemented					
2.1.6 Monitor equipment settings	53%	0. Not implemented	0. Not implemented					
2.1.7 Other	0%	0. Not implemented	0. Not implemented					
2.2 Predictive Maintenance							Early Adaptors = 1,8%	Early Adaptors = 0,6%
2.2.1 PdM via condition monitoring	73%	1. Pilot implementation	3. Fully implemented					
2.2.2 PdM through integrative data analysis	33%	1. Pilot implementation	2. Roll out					
2.2.3 PdM and prescriptive maintenance	33%	1. Pilot implementation	3. Fully implemented					
2.2.4 Other	0%	0. Not implemented	2. Roll out					
2.3 HighPrecision Maintenance							Early Adaptors = 0,2%	Early Adaptors = 0,1%
2.3.1 Precision measurement	27%	0. Not implemented	0. Not implemented					
2.3.2 Laser accurate alignment	33%	1. Pilot implementation	3. Fully implemented					
2.3.3 Accurate calibration of instruments	27%	1. Pilot implementation	2. Roll out					
2.3.4 Managing high tolerances	27%	1. Pilot implementation	3. Fully implemented					
2.3.5 Quality assurance	13%	0. Not implemented	2. Roll out					
2.3.6 Clear maintenance instructions	33%	0. Not implemented	0. Not implemented					
2.3.7 Other	0%	0. Not implemented	0. Not implemented					
3.1 Electrical Energy Optimization							Early Adaptors = 4,9%	Early Adaptors = 2,0%
3.1.1 HVAC optimisation	67%	0. Not implemented	0. Not implemented					
3.1.2 Lighting upgrades	60%	0. Not implemented	0. Not implemented					
3.1.3 Motors and drives	53%	1. Pilot implementation	3. Fully implemented					
3.1.4 Load balancing	33%	1. Pilot implementation	2. Roll out					
3.1.5 Power factor correction	33%	1. Pilot implementation	3. Fully implemented					
3.1.6 Other	0%	0. Not implemented	2. Roll out					
3.2 Thermal Energy Recovery & Reuse							Early Adaptors = 3,6%	Early Adaptors = 3,1%
3.2.1 Heat recovery systems	60%	1. Pilot implementation	3. Fully implemented					
3.2.2 Cogeneration systems	7%	1. Pilot implementation	2. Roll out					
3.2.3 District heating and cooling	0%	1. Pilot implementation	3. Fully implemented					
3.2.4 Integrate industrial processes	20%	0. Not implemented	2. Roll out					
3.2.5 Thermal storage systems	7%	0. Not implemented	0. Not implemented					
3.2.6 Other	0%	0. Not implemented	0. Not implemented					
3.3 Thermal Energy Loss Prevention							Early Adaptors = 2,0%	Early Adaptors = 1,0%
3.3.1 Insulation	73%	1. Pilot implementation	3. Fully implemented					
3.3.2 Thermal imagingand infrared thermography	40%	1. Pilot implementation	2. Roll out					
3.3.3 Temperature sensors	53%	1. Pilot implementation	3. Fully implemented					
3.3.4 Other	0%	0. Not implemented	2. Roll out					
4.1 Fugitive Emission Prevention							Early Adaptors = 0,6%	Early Adaptors = 0,8%
4.1.1 Leak detection and repair (LDAR)	20%	1. Pilot implementation	3. Fully implemented					
4.1.2 Sealing and repair	13%	1. Pilot implementation	2. Roll out					
4.1.3 Emission control technologies	13%	1. Pilot implementation	3. Fully implemented					
4.1.4 Other	0%	0. Not implemented	2. Roll out					
4.2 GHG Capturing & Reuse							Early Adaptors = 0,0%	Early Adaptors = 0,0%
4.2.1 Capture technologies	7%	0. Not implemented	0. Not implemented					
4.2.2 Transport and storage	0%	1. Pilot implementation	3. Fully implemented					
4.2.3 Use and conversion	0%	1. Pilot implementation	2. Roll out					
4.2.4 Biological conversion	7%	1. Pilot implementation	3. Fully implemented					
4.2.5 Other	0%	0. Not implemented	2. Roll out					
4.3 Renewable Energy Generation							Early Adaptors = 3,3%	Early Adaptors = 7,4%
4.3.1 Solar energy systems	67%	1. Pilot implementation	3. Fully implemented					
4.3.2 Wind energy systems	47%	1. Pilot implementation	2. Roll out					
4.3.3 Biomass energy systems	13%	1. Pilot implementation	3. Fully implemented					
4.3.4 Geothermal energy systems	13%	0. Not implemented	2. Roll out					
4.3.5 Other	0%	0. Not implemented	0. Not implemented					
Total							Early Adaptors = 31,1%	Early Adaptors = 28%
Total action plan - Focus Areas					400.000	20.000	2,0%	2,0%

Figure 7.2 | Screenshot of the MORE4Sustainability Self Scan, tab "Focus Areas".

Energy Consumption	Amount	Unit	Price/unit (€)	Costs (€)	ton CO_2-eq / unit	ton CO_2-eq
Fossil Fuels						
Natural Gas		m3			0,00209	
Green / Renewable Gas		m3			0,00038	
Petrol		l		-	0,00285	-
Diesel		l		-	0,00302	-
Liquefied petroleum gas (LPG)	9.000.000	l	0,75	6.750.000	0,00170	15.300
Compressed natural gas (CNG)		kg		-	0,00287	-
Ethanol E85		l		-	0,00106	-
Biodiesel (B100)		l		-	0,00144	-
Coal		kg		-	0,00234	-
Electricity						
Grey Electricity	10.000.000	kWh	0,23	2.300.000	0,00070	7.000
Green Electricity		kWh		-	0,00005	-

Figure 7.3 | Screenshot of the MORE4Sustainability Self Scan, tab "Energy Consumption".

Step 3: Create Business Case & Get Approval

To obtain approval for the prepared action plan, a business case must be developed. The business case is the financial justification for investment projects. Based on Net Present Value (NPV), Return on Investment (ROI), and/or Pay Back Period (PBP) calculations, it can be demonstrated that an investment is profitable. This also applies to sustainability projects!

In step 2 (Perform Self Scan & Set Actions), the costs for implementing the measures were already identified. In step 3, we primarily look at the benefits. The value of sustainability projects lies mainly in Energy Efficiency Improvement on one hand and GHG Emission Reduction on the other.

- **The benefits of Energy Efficiency Improvement** are primarily in reducing energy consumption costs. In the Self Scan, current consumption and costs per type of fuel are displayed (see figure 7.3). By multiplying the total energy costs with the already established improvement in Energy Efficiency Improvement (see step 2), the expected cost savings become clear.
- **The benefits of GHG Emission Reduction** are in reducing the costs of CO_2 emission rights.

Surplus CO_2 emission rights have a market value and can be traded on the EU Emission Trading System (EU ETS). In the Self Scan, CO_2 emissions are calculated from energy consumption, and their value in euros is determined. With the already established improvement target for GHG Emission Reduction, the cost savings on emission rights can be calculated.

Both benefits can be included in the business case (see the example of a business case calculation on the next page).

In the Self Scan, the ROI, NPV, and PBP are automatically calculated. These financial ratios are often decisive for management approval in many companies. If approval is not given, step 2 must be repeated. Then the action plan must be adjusted, the investment level lowered, and possibly the sustainability goals increased.

Example of a business case calculation

A factory with a replacement value of € 300M and a maintenance budget of € 6M has the following energy consumption:

- **Gas** 9,000,000 m^3 x € 0.75/m^3 = € 6,750,000
- **Electricity** 10,000,000 kWh x € 0.23/kWh = € 2,300,000
- **Total** = € 9,050,000

Based on this energy consumption, the CO_2 emissions would be (see figure 7.3):

- **Gas** 9,000,000 m^3 x 0.0017 ton CO_2/m^3 = 15,300 ton CO_2
- **Electricity** 10,000,000 kwh x 0.0007 ton CO_2/kwh = 7,000 ton CO_2
- **Total** = 22,300 ton CO_2

The total cost of CO_2 emissions is:

22,300 ton CO_2 x € 68/ton CO_2 = € 1,516,400

The company has drawn up an action plan delivering 2% energy efficiency and 2% reduction in GHG emissions by 2030 (see figure 7.2). The annual savings are calculated as:

- **Energy Efficiency** 2% x € 9,050,000 = € 181,000
- **GHG Emission Reduction** 2% x € 1,393,388 = € 27,878
- **Total** = € 208,868

The action plan is budgeted as follows:

- **One-time investment:** new motors and LED lighting = € 400,000
- **Additional yearly costs:** new lubrication program = € 20,000

The business case thus becomes:

- **Return on Investment** = 48%
- **Net Present Value** (10 years, 5% discount rate) = € 1,077,384
- **Pay Back Period** = 2 years

From the above ratio analysis it can be concluded that the investment is profitable (ROI = 48%), creates positive value (NPV = € 1,077,384) and is recouped in two years (PBP = 2 years). The project is approved for implementation.

Note: this calculation example assumes 2% improvement in energy efficiency and 2% reduction in GHG emissions. Figure 1.8 shows that the actual improvement potential within companies is often much higher: 31% and 27% on average.

Step 4: Build Foundation & Tactical Enablers

Once the action plan is approved, implementation can begin. This starts with laying a foundation at the tactical level. Chapter 2 already described that this involves the five enablers:

- **Processes:** what do we need to manage risks, implement improvement actions, and achieve lower environmental impacts?
- **Standards:** which standards can be used?
- **Tooling:** what IT systems are needed?
- **Training:** what education, skill and knowledge development is needed?
- **Artificial Intelligence:** how could AI improve efficiency and effectiveness of the new approach?

In step 2 of the Self Scan, improvement actions in these areas were already identified. In step 4, these are implemented to lay a foundation for the more technical improvement projects from the action plan. Without a good foundation in the field of processes, standards, people, and IT systems, these technical projects will not yield maximum returns.

Step 5: Execute & Monitor Action Plan

Once the foundation is laid, the rest of the action plan can be started. These are the actions related to the twelve focus areas from the Framework, covered in chapters 3 through 6.

Each action can be considered a project in itself, with its own project management. From the Maintenance and Asset Management organisation, the coherence between the projects is monitored through a program management organisation.

Projects should be logically ordered, preferably via the 4-step sequence in the Framework: first take care that you have the right assets, then apply good maintenance, then optimise Energy Efficiency, and finally limit GHG Emissions.

Collaboration with solution providers is strongly recommended, as there is a lot of innovation taking place in the field of Sustainable Asset Management at these companies.

Focus areas with the biggest impact

With the benchmark study among the early adaptors we investigated which focus areas within the MORE4Sustainability Framework have the most impact on Energy Efficiency Improvement on the one hand and GHG Emission Reduction on the other. The result of this is visualized in the figure below.

Figure 7.4 | Improvement potential per focus area on Energy Efficiency and GHG Emission.

Based on this overview, we can determine the following top 5 of best practices:

1. **Renewable Energy Generation** (improvement of 7% on GHG and 3% on EEI)
2. **Sustainable Asset Replacement** (improvement of 5% on GHG and 5% on EEI)
3. **Asset Energy Efficiency Care** (improvement of 3% on GHG and 4% on EEI)
4. **Thermal Energy Recovery & Reuse** (improvement of 3% on GHG and 4% on EEI)
5. **Electrical Energy Optimisation** (improvement of 2% on GHG and 5% on EEI)

When drawing up an action plan, it is useful to start with this top 5, provided that nothing has been done in these fields in the past.

Based on the benchmark data of the early adopters, an estimate can then be made of the expected impact on the Energy Efficiency Improvement and GHG Emission Reduction goals. By adding up the impacts of all individual actions, it becomes clear whether the preliminarily set targets are achievable. This insight may lead to adjustments of the targets in the SAMP.

Additionally, the Self Scan also contains an analysis of the strategic and tactical elements from the MORE4Sustainability Framework, so that improvement measures can be formulated for those elements as well.

Step 6: Evaluate & Improve Strategy

The final step in the Implementation Roadmap is the annual improvement cycle.

Sustainable Asset Management programs often span multiple years and require periodic evaluation and adjustment. This involves measuring the progress and costs of individual projects. Deviations are evaluated and translated into corrective measures at the project level.

At the program level, it is measured whether the overall action plan meets the established improvement goals for Energy Efficiency Improvement and GHG Emission Reduction. Here too, corrective measures are initiated if the realisation deviates from the targets.

All insights are incorporated into new updates of the Sustainable Asset Management Strategy, action plan, and business case. In effect, this restarts the MORE4Sustainability Roadmap from the beginning. The Sustainable Asset Management Strategy must be reassessed (are there new sustainability goals at corporate level?), the Self Scan must be performed again (is the current action plan still applicable?), targets must be readjusted (are we making sufficient impact?), and the business case must be updated (is the remaining budget still sufficient?).

Cultural Change

Finally, we want to emphasise that a sustainable transition is only possible when employees are actively involved in the process. Creating support begins with involving employees early on and giving them ownership of sustainable initiatives. By providing employees insight into the choices made and their impact, a shared understanding of the objectives is created. This not only increases engagement but also the chance of successful and lasting change.

Rewarding sustainable behavior through KPIs and incentives also provides a measurable and motivating framework that encourages sustainability.

Transparency in sustainability performance helps identify areas for improvement and offers opportunities for joint optimisation. Sharing information can lead to innovative solutions that contribute to more sustainable business operations.

By promoting a clear communication strategy, a culture of ownership, and transparency, sustainability can become more than just a policy ambition and actually be woven into daily practice. This creates a resilient organisation that not only acts sustainably responsibly but is also economically future proof.

Conclusion and the path forward

From knowledge to action

The industrial sector stands at the forefront of one of the greatest challenges of our time: the urgent need to transition toward sustainable manufacturing. Throughout this report, we have explored the undeniable financial and operational benefits of embracing sustainability-driven Asset Management. Data shows that, at the current pace, manufacturing industries in Northwest Europe might not meet the 55% CO_2 reduction target by 2030 and, may account for half of all excess emissions by 2045 if no decisive action is taken.

The MORE4Sustainability Framework provides a clear, structured approach to integrating sustainability into Maintenance, Repair, Overhaul, and Engineering (MORE). This framework is built on real-world best practices, offering practical, replicable strategies.

The early adopters demonstrated that they have already implemented various Sustainable Asset Management practices and are reaping the benefits of these proactive sustainability strategies. They are improving energy efficiency, reducing greenhouse gas emissions, lowering costs, improving resilience and positioning themselves as leaders in the low-carbon economy. This shows that Sustainable Asset Management can indeed make a difference.

Yet, knowledge alone is not enough. Reading about best practices is valuable, but implementing them is what drives true impact. The companies that will thrive in the coming decades are those that move beyond awareness to execution, those that actively integrate sustainability into their core business strategy.

Your role in the transition to a more sustainable industry

It is important that we take action. Waiting is not an option. Regulations will tighten, energy costs will rise, and the pressure to decarbonise will only increase. Those who take action now will not only secure cost savings and compliance, but will also build resilient, future-proof operations that attract investors, customers, and top talent.

The path forward is clear:

1. Assess where you stand today. Conduct an internal sustainability audit using the MORE4Sustainability Framework and the MORE4Sustainability Self-Scan. Identify inefficiencies, energy losses, and high-emission processes.
2. This leads to an overview of your improvement potential. Use the MORE4Sustainability Framework to prioritise impactful, low-cost initiatives that can deliver immediate energy and emission reductions.
3. Invest in training and technology. Empower your workforce with the knowledge and tools needed to implement Sustainable Asset Management strategies effectively.
4. Collaborate within your industry. Sustainability is not a competitive advantage if only a few companies succeed, the entire sector must transform to meet climate goals. Engage in industry partnerships, knowledge-sharing networks, and collaborative innovation.
5. Commit to continuous improvement. Sustainability is not a one-time project; it is an ongoing process. Set measurable targets, track progress, and refine strategies to ensure long-term success.

This is your moment to lead. The data is clear, the solutions are available, and the urgency has never been greater. The only question is: will you be at the forefront of this transformation, or will you be forced to catch up?

Choose a future that is both profitable and responsible. The time to act is now.

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⇒ Project website: more4sustainability.nweurope.eu

Lead partner organisation

BEMAS BRIDGE TO SUSTAINABLE ASSET PERFORMANCE

Belgian Maintenance Association

⇒ www.bemas.org

Project partner and leading the execution

mainnovation

Consultancy firm and experienced research agency

⇒ www.mainnovation.com

Project partners

NVDO

Dutch Society for Purposeful Maintenance

⇒ www.nvdo.nl

EMC2

EMC2 Competitiveness Cluster

⇒ www. pole-emc2.fr

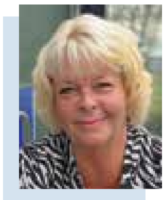
FVI

Forum Vision Maintenance

⇒ www.fvi-ev.de

Steering Committee

Wim Vancauwenberghe
Director, BEMAS
⇒ wvc@bemas.org



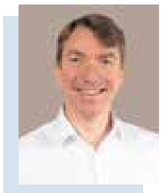
Ellen den Broeder
Association Manager, NVDO
⇒ ellen.den.broeder@nvdo.nl

Océane le Bot
Development Manager,
Pôle EMC2
⇒ oceane.le-bot@pole-emc2.fr

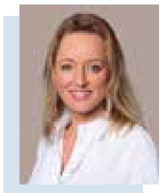
Harald Holzvoigt
Member of the board, FVI
⇒ holzvoigt@fvi-ev.de

Research Team Mainnovation

Mark Haarman
Managing Partner
⇒ mark.haarman@mainnovation.com

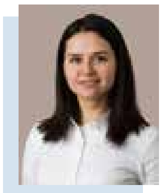


Géry Thellier

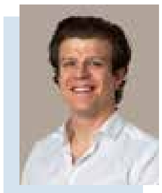


Laura van der Linde

Jasper Lipsch
Managing Consultant
⇒ jasper.lipsch@mainnovation.com

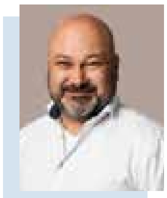


Yoanna Nedelcheva



Thomas Wlazlo

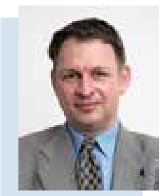
Rob van Dongen
Executive Consultant
⇒ rob.van.dongen@mainnovation.com



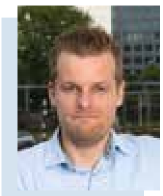
Soefjen Tmalla

Expert board

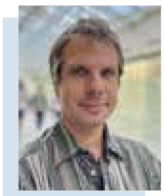
Contributed to the development of the MORE4Sustainability Framework



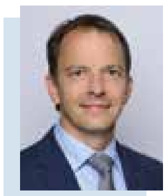
Pierre Dehombreux
Professeur Mechanical Design and Production Engineering at Faculté Polytechnique de Mons.



Willem Haanstra
Assistant Professor in Sustainable Asset Management at University of Twente.



Pierrick Haurant
In charge of in-depth techniques in the field of energy and environmental transitions and Master Assistant at IMT Atlantique University.



Lennart Brumby
Studiengangsleiter Service Engineering at State University Baden-Württemberg Mannheim.