Non-electrification based energy savings in Dutch Industries

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Content

Introduction: Strengthening Insight into Industrial Energy Conservation

The Ministry of Climate Policy and Green Growth (KGG) is working to deepen understanding of energy conservation in Dutch industry. This initiative focuses on three areas:

1. **Mapping the energy conservation trajectory** (2024 Climate and Energy Outlook to 2030) and comparing it with technical potential estimates from TNO.

2. **Assessing additional energy conservation potential** beyond current expectations, distinguishing between electrification (e.g., heat pumps, electric boilers) and other energy-saving measures (e.g., thermal management, , engine efficiency, digital optimisation).

3. **Translating additional potential into policy interventions.**

In addition, there is a need for insight into the technical/economic potential of measures other than electrification. These include measures aimed at improving thermal management, improving cold management, optimizing , improving engine efficiency, using artificial intelligence and/or digital twin for process optimisation.

For non-electrification measures, KGG has asked TNO to compare the energy saving potential reported by companies (Resultaten energiebesparingsplicht) with findings from literature, for the remaining of the report it will be referred to as the RVO report. Thus, this slide deck focuses only on the part of that initiative concerning non-electrification energy-saving measures and their technical/economic potential.

Research Questions:

- Which studies and sources provide further insight into the potential of energy-saving measures other than electrification in Dutch industry?
- How does the saving potential in literature compare to the saving potential reported in the RVO report?

How?

This slide deck will guide you through a simplification of the RVO report, reviewed relevant literature on non-electrification energy-saving measures in Dutch industry, comparison of the savings potential from both sources by measure type and payback period.

Re-cap: the RVO report

Purpose of the RVO Report
The report provides an overview of the implementation and results of the Dutch energy savings obligation for businesses and institutions. It tracks compliance, reported measures, and the effectiveness of policies requiring cost-effective energy-saving actions. The focus is on measures with a payback period of five years or less, as required by law.

Key Points (excluding electrification)

- The report is not about promoting electrification (such as switching from gas to electric heating or vehicles), but about all energy-saving measures that reduce energy consumption, regardless of the energy carrier.
- Examples of non-electrification energy-saving technologies and measures discussed include: →

What is energy savings potential?
The estimated amount of energy that can be reduced or conserved within a process, sector, or system by implementing efficiency measures or technological improvements. It is usually expressed as a percentage of current energy use or in absolute units (such as PJ or kWh).

In practice, this potential represents the gap between current energy consumption and what could be achieved if all technically feasible measures were applied

Improved insulation
(e.g. roof, wall, pipe insulactond, tins)

Heat recovery
(e.g. economisers, heat exchangers, using waste heat)

Process optimisation
(e.g. better process control, reducing losses)

Efficient lighting
(e.g. LED, controls)

Ventilation and heating controls
(e.g. weather-dependent regulation, clock controls)

Use of residual heat
and reduction of unused heat flows

Upgrading or optimising existing equipment
in industry

Behavioural and organisational measures
(e.g. energy management, monitoring, staff training)

Re-cap: Quick scan MIDDEN, P6-25, and other

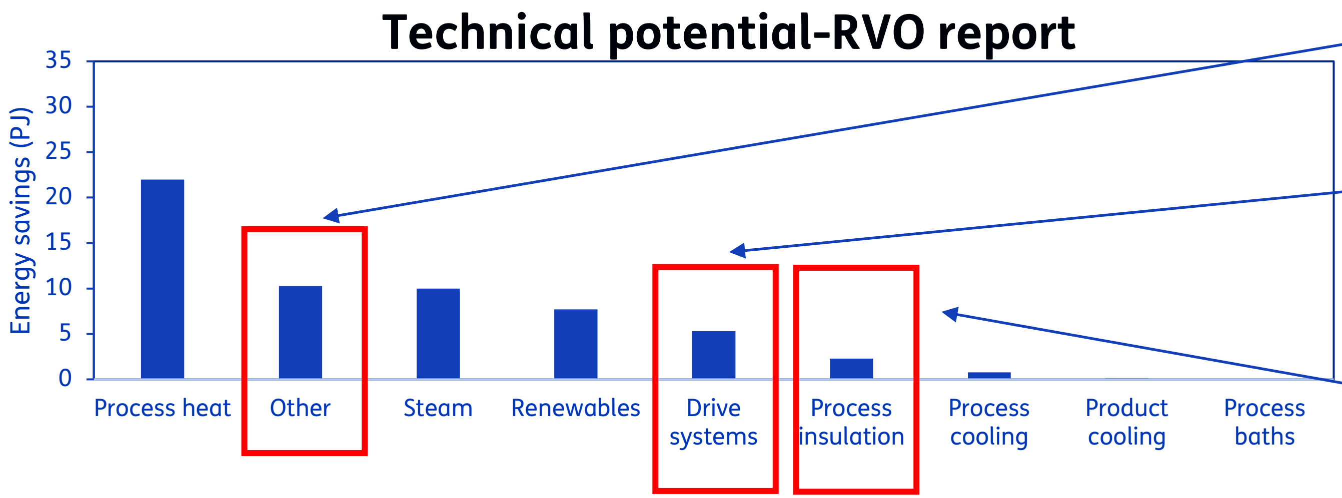
MIDDEN: The report provides an overview of energy efficiency measures and their technical potential across the Dutch manufacturing industry, based on the MIDDEN database, literature, and interviews. It focuses on process efficiency within industrial sites, not on value chain efficiency, electrification, or renewable energy. The study compares its findings with the P6-25 technology validation study, which assessed innovative energy efficiency measures for Dutch industry.

P6-25: The report independently validates the cost-effective and proven CO_2 reduction potential that can be realised in Dutch industry by applying 15 preselected innovative technologies. The focus is on measures that can be implemented before the end of 2025, are proven at scale (TRL 8 or 9), and have a payback period of five years or less (including subsidies). Feasible technical potential: ~6 Mton CO_2/year (not all cost-effective)

AR6 (2022): The industry chapter highlights that Industrial electrification is most viable where processes are simple, need little modification, use low-temperature heat, do not rely on CHP, and have access to low-cost electricity and that energy efficiency is a key mitigation strategy, with measures such as high-efficiency motors, heat recovery, and smart energy management offering energy savings. Electrification of heat and material efficiency are also emphasised for long-term decarbonisation.

IEA Energy Efficiency 2023: The 2025 edition of the IEA's efficiency report highlights that global energy efficiency progress is estimated to reach 1.8% in 2025, an improvement from around 1% in 2024, though still well below the COP28 target of 4% annual improvement by 2030. The report specifically notes that stronger minimum performance standards for equipment such as motors and air conditioners remain essential to close existing policy gaps and accelerate efficiency gains.

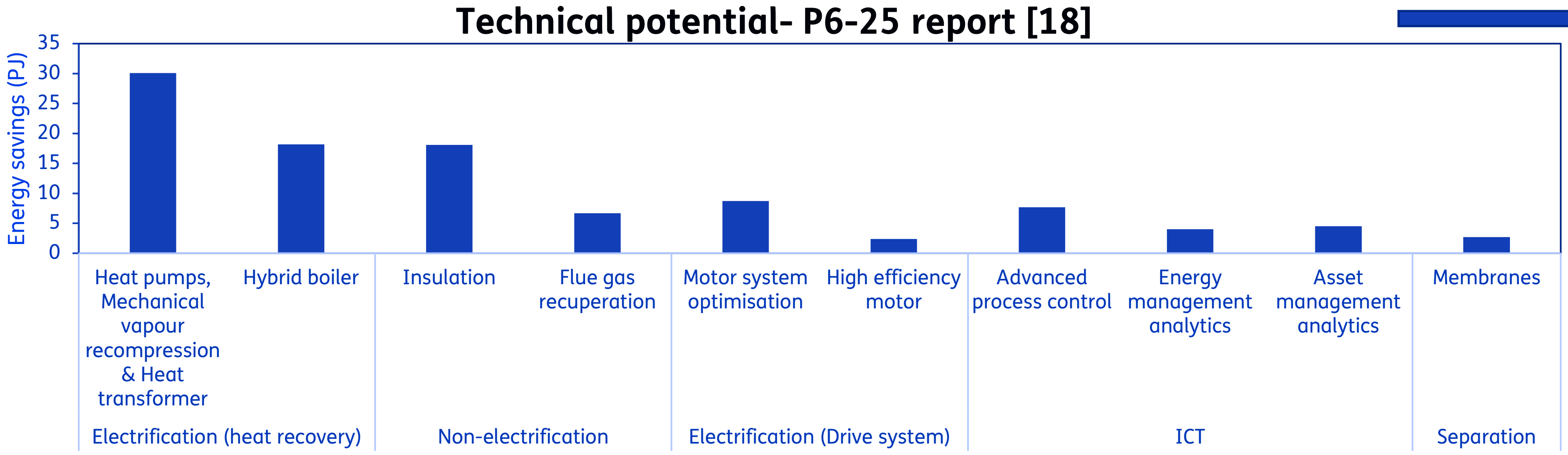
Re-cap: Energy saving technologies & potential



The ''other'' in RVO report is not clear and does not mention technologies like Flare gas, ORC, process control, maintenance

In the study by France [1], drive systems accounted for highest energy savings potential, second highest as per EU 27 industrial sector 2030 scenario [12] & roughly 70% of electricity consumed by industry is used by electric motor systems [14]

Potential energy savings in the Netherlands with industrial = 40 PJ (as per European Industrial Foundation report [8])



The P6-25 report breaks down savings potential by specific technologies (e.g., heat pumps, , advanced process control), providing a granular view of where interventions can be made. In contrast, the RVO report aggregates potential by process categories (e.g., process heat, steam), offering a broader, system-level perspective.

Re-cap: Energy savings potential (PJ/y) in Dutch industries by 2030 (sector-wise)

Table 2. Technical potential described in selected reports

Sector	Technical Potential Estimate MIDDEN (PJ/y)	Technical Potential Estimate P6-25 (PJ/y)	Technical Potential RVO Report (PJ/y)	Comments based on: Industriële elektrificatie & efficiëntie – notitie aan KGG (TNO 2025)
Organic chemicals/ Steam crackers	17	13	n/a	The report shows large technical gains from electrifying steam cracker furnaces and compressors; furnace heat demand can drop by ~35–50%.(Chapter 4.3.1)
Refineries	n/a	16	6	Many refinery heaters and drives are technically electrifiable, but steam-system integration, refinery-gas handling, grid capacity and the expected decline of the refining sector strongly limit the achievable electrification. This is reflected in the very low quantified potential for refineries (≈1 PJ/y for heat-pump applications), with no large PJ totals identified for high-temperature electrification. (Chapter 4.3.2;3.3)
Other industries	5	n/a	3	No comment.
Food and Beverages	7	20	16	Most heat is <200 °C; strong heat-pump potential in drying, evaporation and pasteurisation, plus non-thermal options. This explains the 7 PJ/y. (Chapters 3.2, 3.3, 5.2)
Wider chemical industry	n/a	18	21	Distillation steps fit heat pumps and drive a high absolute PJ/y potential in the chemical industry (~32 PJ/y); membranes and electric drives provide additional, mainly enabling efficiency gains.(Chapters 3.2.2, 3.3, 5.1, 5.3)
Fertiliser	1	3	n/a	Ammonia production relies largely on natural gas as feedstock rather than process heat, leading to limited heat-related electrification potential; the report does not provide a detailed process-level analysis of ammonia production.(Chapters 2, 3.3, 4.3.2)
Iron and Steel	5	5	1	Report gives only high-level notes (and CBS data caveats), not electrification pathways (Chapter 2)
Paper and Board	8	10	2	Drying dominates; heat pumps can cover up to ~80% of heat demand; 9 PJ heat-pump potential (Chapters 3.2.1, 3.3)
Industrial gases	n/a	2	n/a	SMR is heat- and feedstock-intensive; electrolyser waste-heat recovery is limited at low temperature, so small PJ/y(Chapters 2, 3.3, 6.1.2)
Total	43	87	50	
Energy savings potential (%)	**6%**	**13%**	**7%**	

*Industriële elektrificatie & efficiëntie – notitie aan KGG (TNO 2025)”

Re-cap: Energy savings potential (PJ/y) in Dutch industries by 2030 (sector-wise)

The table compares technical energy-saving potential across major industrial sectors based on three studies, MIDDEN, P6-25 and the RVO report, and is complemented with process-level insights rom a recent TNO analysis. While all studies identify opportunities for improvement, their numerical estimates differ markedly. P6-25 reports the highest overall potential at 87 PJ/y (approximately 13% of industrial final energy use), compared with 43 PJ/y (6%) in MIDDEN, while the RVO assessment falls in between at 50 PJ/y (7%).

At sector level, this intermediate positioning of RVO is visible in several cases. For food and beverages, RVO estimates around 16 PJ/y, higher than MIDDEN (7 PJ/y) but lower than the P6-25 estimate of 20 PJ/y. A similar pattern is observed in refineries, where RVO (6 PJ/y) is substantially lower than P6-25 (16 PJ/y), reflecting a more restrictive view on realistic deployment. In contrast, for the wider chemical industry, the RVO estimate (21 PJ/y) exceeds the P6-25 value (18 PJ/y), consistent with the TNO report's identification of large, low-temperature distillation potentials. For paper and board, RVO reports a markedly lower potential (2 PJ/y) than both MIDDEN (8 PJ/y) and P6-25 (10 PJ/y), indicating a conservative assessment focused on near-term, implementable measures.

In several smaller or structurally constrained sectors, such as fertilisers, industrial gases, and parts of iron and steel, RVO does not quantify a potential, while MIDDEN and P6-25 identify only small technical savings (typically 1–5 PJ/y). This difference reflects a distinction between technically identifiable options and measures considered realistically deployable at scale in the near term. The TNO analysis supports this interpretation by showing limited heat related opportunities. Finally, while paper and board show only moderate absolute PJ values, the TNO report highlights that this sector stands out for a very high share of technically electrifiable heat demand. up to around 80%. due to the dominance of drying processes.

* "Industriële elektrificatie & efficiëntie – notitie aan KGG (TNO 2025)"

Selected categories & technologies for literature review

The table shows main categories (non-electrification, ICT & Maintenance, electrification) with sub-categories like heat recovery, , process control, maintenance, and drive systems. For each sub-category, it lists technologies from the RVO report (e.g., economisers, flue gas condensers, frequency-controlled pumps) and additional options for review (e.g., air preheaters, residual heat recovery, AI-based control, high-efficiency motors).

The following slides present a literature review of these technologies, reflecting the most recent insights into their capabilities and potential. We identified relevant literature using several sources, including expertise from TNO colleagues, online research, guidance from KGG. We also reviewed previously used literature and examined older documentation to identify updated or more recent versions of key sources. After identifying the sources, we reviewed each document in detail to extract the information requested. For each source, you'll find the title, author(s), and a description of the focus of the document

Following the review, information on these key technologies is presented, including their category, application, estimated savings potential, and source references.

Table 3. Selected categories & technologies for literature review, based on technologies reported in the RVO report

Categories	Sub-category	Example of technologies (RVO report)	Example of technologies (additional)
Non-electrification	Heat recovery	Economiser, flue gas condenser	Air preheater, residual heat from compressors, flare gas heat recovery, steam systems energy savings
		Heat & cold s	NA
ICT & Maintenance	Advanced process control	Frequency controlled pumps, energy monitoring system	Frequency controlled fans, AI based process control
	Maintenance	NA	Periodic inspection with thermographic camera, ultra-sonic leak detection, maintenance of steam traps
Electrification	Drive systems	Heat pumps, mechanical vapour recompression	Using high efficiency motors
	Other	NA	Microwave drying, Organic Rankine Cycle

Literature review and short description

Number	Author(s)	Title (With link)	Short Summary	Year
1	ADEME	French Know-How in the Field of Energy Efficiency in Industry	Overview of France's industrial energy-efficiency expertise and programmes, highlighting R&D support, pilot projects, and practical solutions for utilities/processes to cut energy use and emissions.	2013
2	Campana, Bianchi, Branchini, De Pascale, Peretto, Baresi, Fermi, Rossetti, Vescovo	ORC Waste Heat Recovery in European Energy Intensive Industries: Energy and GHG Savings	EU-wide assessment of Organic Rankine Cycle opportunities in cement, steel, glass and oil & gas, estimating up to ~20,000 GWh/yr of heat recovery and ~7.6 Mt CO_2 savings in a favourable scenario.	2013
3	De Buck; van Lieshout; Croezen; van der Post; Jordan	Energiebesparende maatregelen voor vergunningplichtige industriële bedrijven	Practical "low-hanging fruit" factsheets for Dutch permit-holding industry, detailing ten quick-payback measures to meet the <5-year payback legal duty and improve competitiveness.	2014
4	Papar; Harrell; Venkatesan (UNIDO)	Manual for Industrial Steam Systems Assessment and Optimization	Comprehensive UNIDO guide for auditing and optimising steam systems (generation, distribution, end-use) with methodologies, tools, and typical savings measures.	2016
5	Fawkes; Oung; Thorpe (UNEP DTU)	Best Practices and Case Studies for Industrial Energy Efficiency Improvement – An Introduction for Policy Makers	Policy-oriented handbook covering barriers and policy instruments (information, regulatory, fiscal, innovation) with global case studies to accelerate industrial energy efficiency.	2016
6	Siemons; Katakwar; Croezen; Helmi; van der Pol; Blahusiak; Mahmoud; den Haan; Flick; Verkaik	Project 6-25 Technology Validation	Dutch validation study (FME/VEMW) of 15 near-term technologies (motors/drives, heat integration, ICT, separations, flexibility) showing ~3 Mt CO_2 feasible reduction by 2025 under favourable paybacks.	2020
7	Semmari; Filali; Aberkane; Feidt; Feidt	Flare Gas Waste Heat Recovery: Assessment of ORC for Electricity Production and Possible Coupling with Absorption Chiller	Case study (Algeria) modelling ORC on flare gas, optionally coupled to an absorption chiller, demonstrating electricity/cooling potential and associated CO_2 abatement from flaring.	2020
8	European Industrial Foundation (EiiF)	The Contribution to Decarbonise Industry (EU-27)	Quantifies EU industrial potential: ~14 Mtoe annual energy savings and ~40 Mt CO_2 reductions with short average paybacks when upgrading to VDI 4610 energy class C.	2021
9	ABB	Energy Efficiency in Iron and Steel Making	Outlines energy-efficiency opportunities in steel (motors/drives, power quality, boiler optimisation, digital energy management) in support of decarbonisation pathways (EAF, H_2, recycling).	2021
10	Asadi; Yazdani; Hosseinzadeh Dehaghani; Kazempoor	Technical Evaluation and Optimization of a Flare Gas Recovery System for Improving Energy Efficiency and Reducing Emissions	Process simulation and multi-objective optimisation of an amine-assisted liquid ring compressor FGR system; recovering ~87% of heating value for a 0.5 MMSCFD flare and avoiding ~28 tCO_2e/day.	2021
11	ABB	Overcoming Energy Efficiency Challenges in the Water and Wastewater Industry	Vendor guidance on pumps/motors/drives, process automation and energy management for water/wastewater utilities to cut energy use and OPEX.	2021
12	Directorate-General for Energy, CE Delft, Eclareon and ICF	Technical Assistance Services to Assess the Energy Savings Potentials at National and European Level	EU technical assistance report quantifying energy-savings potentials and policy pathways across Member States (methodologies, national potential estimates).	2023

Literature review and short description

Number	Author(s)	Title (With link)	Short Summary	Year
13	Wetzels; Menkveld; Oliveira (TNO)	Verwachte effecten van de energiebesparingsplicht uit de Wet Milieubeheer (TNO 2020 P11691)	Assesses expected impacts of the Dutch legal energy-saving duty (obligation to implement ≤5-year payback measures), including sectoral effects and compliance pathways.	2021
14	ABB	Achieving the Paris Agreement – The Vital Role of High-Efficiency Motors and Drives in Reducing Energy Consumption	Argues that upgrading motor-driven systems with high-efficiency motors and variable speed drives can reduce global electricity use by up to ~10% with typical 1–3-year paybacks.	2021
15	ABB	Concrete Steps for an Energy-Efficient Future with the Top Industrial Efficiency Option	Practical measures for industry to cut energy use via electrification, efficient drives/motors and digital optimisation; highlights rapid ROI and compliance with MEPS.	2022
16	Hajlasz; Helmcke; Liebach; Schleyer; Somers	Waste Not: Unlocking the Potential of Waste Heat Recovery	Executive-style report describing industrial WHR potential, barriers (temperature/quality, capture/use), and solution pathways (ORC, heat pumps, integration).	2023
17	Grundfos	Ras Al Khaimah Saves 20% Energy and 12% OPEX in Wastewater Pumping System	Case study showing pump system optimisation and controls delivering ~20% energy savings and ~12% OPEX reduction in a wastewater network.	2023
18	Haque; Lamboo (PBL/TNO)	Energy Efficiency Options in the Dutch Manufacturing Industry	Survey and literature review mapping the most relevant industrial energy-efficiency options in NL manufacturing, with indicative potentials and barriers by subsector.	2023
19	Brunsvold; Røkke; Nekså; Claussen; Zondag; van Delft; Worrell; Grijns-Graus; Alonso; Drexler-Schmid	The Role and Impact of Energy Efficiency in Decarbonising European Industry	Synthesis of how efficiency measures interact with electrification, CCS and hydrogen across EU industry; identifies system value and priority actions.	2024
20	Saviuc; Oluleye	Calculating the Investment Needs in European Industry for the 2030 Energy Efficiency Targets	Framework to estimate capex required for EU industrial efficiency targets, allocating by sector/measure and considering payback constraints.	2024
21	Rosenow; Arpagaus; Lechtenböhmer; Oxenaar; Pusceddu	The Heat Is On: Policy Solutions for Industrial Electrification	Academic review proposing policy packages to scale industrial heat pumps and electrification, addressing economics, infrastructure and regulatory barriers.	2025
22	Rosenow; Arpagaus; Lechtenböhmer; Oxenaar; Pusceddu	The Heat Is On: Policy Solutions for Industrial Electrification	Academic review proposing policy packages to scale industrial heat pumps and electrification, addressing economics, infrastructure and regulatory barriers.	2025

* This overview also includes certain electrification measures because they were either not covered in the report "Industriële elektrificatie & efficiëntie – notitie aan KGG (TNO 2025)" or were explicitly requested by KGG to be included in this brief overview

Literature review and short description

Number	Author(s)	Title (With link)	Short Summary	Year
23	Fu; Cao; Gao	Current Status, Problems and Promotion Strategies of AI Application in Industrial Energy Management: A Case Study from China	Journal paper identifying AI use-cases (prediction, optimisation), barriers (data, skills, integration) and strategies to scale AI-enabled energy management in industry in China.	2025
24	Faith Victoria Emmanuel, Joshua Moses	A Comparative Study of Traditional vs AI-Based Maintenance Strategies in Minimising Energy Loss in Manufacturing Plants	Compares rule-based maintenance with AI-driven predictive approaches, finding reduced energy losses and downtime with data-driven maintenance workflows.	2025
25	Ling-Chin; Roskilly	Industrial Heat and Energy Efficiency	Book-length treatment on industrial heat demand, technologies (waste heat, heat pumps, electrification) and system integration to boost efficiency.	2025
26	KCORC	Thermal Energy Harvesting – The Path to Tapping into a Large CO_2-Free European Power Source	Report on converting industrial low-grade heat into power via ORC/related cycles, outlining European potential and technology pathways.	2025
27	AR6	Working Group III – Industry Chapter	Provides mitigation strategies for industry, including energy efficiency, electrification, material efficiency, and cost-effectiveness analysis.	2023
28	International Energy Agency (IEA)	Energy Efficiency 2025 Report	Analyses global energy efficiency trends, sector-specific measures, and payback periods for industrial technologies.	2025
29	International Energy Agency (IEA)	World Energy Outlook 2025	Offers scenarios for energy demand and decarbonisation, including industrial energy efficiency and electrification pathways.	2025
20	European Commission	Energy Efficiency Directive (EED)	Sets mandatory energy audits, energy management systems, and efficiency obligations for large enterprises in the EU.	Latest consolidated version (2018/2023 updates)
31	Fraunhofer Institute for Chemical Technology ICT ; Schröder, Liebertseder; Doppelbauer	Study on the Energy-Saving Potential of Electric Motors with Variable-Speed Drives in the European Union – Final Report	Overview of the EU-wide energy-saving potential of variable-speed drives s) in pumps, fans, and compressors, quantifying both technical and realistic savings based on market conditions.	2023
32	IEA	Energy and AI	analyses how artificial intelligence affects the energy system, covering both the electricity needed to power AI and the efficiency gains AI can unlock, including in industry. It highlights how industrial applications such as process optimisation and predictive maintenance can reduce energy use and emissions.	2025

Next step and EML explained

The literature review identified a range of technologies. For each one, we gathered key details: Type of technology, application, potential energy savings.

To assess their relevance in practice, we compared these technologies against the Recognized Measures List (EML). The EML is a Dutch government list of cost-effective, technically feasible energy-saving measures with a payback period of five years or less. Companies with significant energy use must report via the RVO eLoket which measures they: Have implemented, plan to implement, have justifiably not applied. Each measure on the EML has a unique code identifying the sector, system, and measure number. Guidance on reading these codes is shown on the right.

For every technology in our review, we indicate whether it appears on the EML using these icons: 🟢 On the list | 🔴 Not on the list | 🟡 Indirect effect. The EML is effect-based, meaning alternative measures are allowed if they achieve equal or greater energy savings. These alternatives require a substantiation report (onderbouwingsplicht).

The next five slides present this information in table format per technology category.

How to Read EML Codes:

- **Two letters**: The main category or system (e.g. FA = Compressed air, FB = Steam, FC = Electric drives, FD = Cooling, PB = Drying, PF = Process cooling, PE = Process heat, etc.)
- **A number**: The specific measure within that category (e.g. FA2, FB3, FC1).

Example:
•**FB3**

- **F** = Facility/process
- **B** = Steam & boilers
- **3** = Use a flue gas condenser to recover heat

How to use:

- The code tells you where to find the measure in the official EML list and helps with reporting and compliance.
- The letters show the system or process; the number shows the specific action.

Key technologies : Heat recovery

Category	Technology	Application	EML code	Savings potential (as reported)	Source
Heat recovery (Low temperature heat (T<100 ºC) need in the Netherlands = 54 PJ [6])	Innovative hot air recycling circuit, optimised use of the drying chambers and automatic regulation of the ventilation circuits by CLEIA, France*	In the service of brick and tile production	🟢 PB1, PB2 (Humidity sensor + recirculation control)	Saves up to 15% of the gas used in drying the tiles	[1]
	Maguin has designed and installed a "low-temperature" belt dryer based on recovering energy from the drying line fumes*	On behalf of the Cristal Union sugar plant in Bazancourt	🟡 PB2 (Humidity sensor + recirculation control)	Upgrade of €0 heat to €45 heat	[1], [16]
	Flue gas condenser*	Heat exchanger used from 80°C with flue gas	🟢 FB3 – Use a flue-gas condenser to recover heat	5-10% & €20-30/kW installed capacity. 15% to 20% of the energy in the burnt fuel lost through the chimney. Economizers are a mature and well-known technology and can save between 3% and 7% of fuel burn	[3], [5], [18],[19], Heat recovery at low flue gas temperatures - Heat Matrix
	Hot *	of hot pipes	🟢 FB5 – Insulate uninsulated hot parts of the steam boiler FB6 – Insulate steam lines and fittings	85–95% & €100-600 per accessory. 3%-4% of energy is lost due to damaged s in Dutch industries. 70-80% reduction of energy loss by insulating uninsulated pipes	[3], [6], [8]
	Flare gas heat recovery	Waste gas to heat or power	🔴 -	Payback time of about 3-5 years. Gas flaring burns about 150 billion m3 of natural gas around the world.	[7], [10], [20]

* Use of heat pumps reduces the potential for other heat recovery options

🟢 On the list 🔴 Not on the list 🟡 Indirect effect (Erkende maatregelenlijst (EML) 2023 - berekeningen_v1-4.xlsx)

Key technologies: ICT

Category	Technology	Application	EML code	Savings potential (as reported)	Source
ICT	A speed regulator or frequency controller is an electrical control which adapts the mechanical power requirement and thus, the electricity consumption of a drive system.	Motor of pumps & fans	🟢 FC1 – Apply frequency control on machines (Variable Speed Drives) and FC2 (Pumps)	Energy savings in operation of up to 50%. Optimizing the control of pumping systems in wastewater treatment plants could result in 10 to 20% energy savings	[1], [11], [17]
	Permanent magnet synchronous variable speed motor (Dyneo®, 390 kW, 3600 rpm) by Leroy Somer	Improve cooling chamber processes for deep-freezing at the premises of Cooperl in Lamballe (France), a specialist in pork production	🟢 Not the same name but FC1 – Apply frequency control on machines (Variable Speed Drives)	Saving of 250,000 kWh/year with a return on investment in about 30 months	[1]
	Frequency controlled pumps	Motor of pumps	🟢 FC2 – Apply frequency control on pumps	20–50% & €100-600/kW	[3], [12]
	Variable speed drives (VSD)*	Allows the motor speed to be varied from zero to its maximum rated speed, so it can match the actual power demand of the load.	🟢 FC1 – Apply frequency control on machines (Variable Speed Drives)	Can reduce energy consumption between 20% and 70%. VSD penetration in Europe is no higher than 15%.	[5], [31]
	Advanced process control, energy management analytics, asset management analytics, AI in process control	Process control, predictive maintenance, scheduling, quality control	🔴	1-3% energy savings and payback less than 2 years. Energy consumption reduction of 15% by enhancing process efficiency in cement industry. AI-enabled optimisation in industry can unlock 2–6% energy savings in energy-intensive industries.	[6], [19], [20], [23], [24],[28]

** VSDs are included under ICT because their energy savings come from information, control, and digital optimisation, rather than from intrinsic improvements in motor efficiency.

🟢 On the list 🔴 Not on the list 🟡 Indirect effect (Erkende maatregelenlijst (EML) 2023 - berekeningen_v1-4.xlsx)

Key technologies: Maintenance

Category	Technology	Application	EML code ((The EML sees maintenance as a supporting action)	Savings potential (as reported)	Source
Maintenance	Reduce leaks in compressed air systems	Process control air, pneumatic systems	🟡 It can be connected to: FA1 – Increase the compressed-air buffer, FA2 – Install a time-controlled shut-off valve to avoid off-hours losses, FA3 – Apply a flow–pressure regulator in the compressed-air network	25% savings potential	[1]
	Periodic thermographic inspection of	€6,000 per inspection/report	🟡 Supporting action for FB5/FB6/PE2 (no separate code in the workbook)	Assists to detect heat losses quicker	[3], [4]
	Compressed air: ultrasonic leak detection	Ultrasonic detector: approx. €2,000	🟡 Not directly but connected to: FA1/FA2/FA3.	5-30%	[3], [4]
	Periodic cleaning of air coolers (air fin banks).	Approx. €1,000/ Air fin bank cleaning	🟡 Cleaning itself isn't a standalone measure in the EML; it enables the performance of other listed cooling measures (FD)	20–40%	[3]
	Periodic maintenance of steam traps & maintaining a steam trap database is essential for an effective steam trap management program	Replacement approx.: €500/condensation trap	🟡 Supporting the FB steam-system measures	Even a well-maintained steam system will typically experience a 10% trap failure in a 1-year period. If unchecked, this can translate into significant economic losses and operational issues to the system.	[3], [4]

🟢 On the list 🔴 Not on the list 🟡 Partially on the list (Erkende maatregelenlijst (EML) 2023 - berekeningen_v1-4.xlsx)

Key technologies: Electric, drive systems

Category	Technology	Application	EML code	Savings potential (as reported)	Source
Electrical drive systems)	IE motors	IE1: standard efficiency; IE2: high efficiency; IE3: "premium" efficiency; IE4: category under development, although motors are already coming to market	🟢 FC4 – Replace IE2 or lower motors with IE4 or higher FC5 – Replace IE3 motors with IE4	The range of efficiency between IE1 and IE4 motors, depending on motor size and type, can vary by 5% or more. An IE5 level is envisaged for future use with the goal of further reducing energy usage compared to IE4 by 20%.	[1], [5], [14], [15]
	IE5 SynRM motors by ABB	Motor of pumps	🟡 It claims to be ''higher performance'' Not specified by EML on brand or technology but it could fit: FC4 – Replace IE2 or lower motors with IE4 or higher FC5 – Replace IE3 motors with IE4	Up to 40 percent lower energy losses compared to IE3 induction motors. Motor systems account for around 7% of the energy use in steel industry, it has been estimated that up to 70% of the energy consumed by these motors is lost due to system inefficiencies	IE5 SynRM motors — ABB Group, [9]
	Dry coolers	Replacing cooling towers with dry coolers	🟢 PF2 - Dry coolers (replacing cooling towers / process free-cooling)	20–50% & €100-600/kW	[3]

🟢 On the list 🔴 Not on the list 🟡 Indirect effect (Erkende maatregelenlijst (EML) 2023 - berekeningen_v1-4.xlsx)

Key technologies: Other electrification

Category	Technology	Application	EML code	Savings potential (as reported)	Source
Electrification (other)*	Installation of an Organic Rankine Cycle machine in a foundry by ENERTIME	Extract electricity from medium temperature sources of waste heat (water at 150°C, fumes at 250°C etc.) dissipated in the production of raw materials (metals, cement, glass etc.).	🔴 Custom/alternative measure (not listed; requires justification)	Solution enables FMGC to generate up to 30% of its electricity requirements with no additional consumption or emissions. €30 heat to €140 electricity	[1], [16]
	ORC power recovery	Considering only the following sectors: cement, steel (EAF and rolling mills), glass (float furnaces) and gas compressed stations in Europe, the installation of 2705MW of ORC gross power has been estimated. (In Netherlands 89 MW ORC power recovery possible from gas compressor stations as per source)	🔴 Custom/alternative measure (not listed; requires justification)	This ORC power installation potential would lead to up to 21.6 TW h per year of electricity production a value which represents almost 2% of the European Industry consumption.	[2], [26]
	Hybrid boilers*	Steam boilers	🟡 In building heating, the workbook's hybrid code would be GC2 (Add an electric heat pump alongside existing boiler).Industry-specific "hybrid boiler" isn't a standalone code.	In addition, due to its low turndown ratio it may also save standby energy consumption from approximately 10% of consumed on-site heat	[6], [21]
	EcoTransFlux, a transverse flux induction heating oven developed by Fives Celes, France.*	To heat materials, such as aluminium, steel, Gen3 AHSS with heating capability: up to 1,200°C	🔴 Custom/alternative measure (not listed; requires justification)	Thermal efficiency above 75% regardless of strip format	[1]

* This overview also includes certain electrification measures because they were either not covered in the report "Industriële elektrificatie & efficiëntie – notitie aan KGG (TNO 2025)" or were explicitly requested by KGG to be included in this brief overview

🟢 On the list 🔴 Not on the list 🟡 Indirect effect (Erkende maatregelenlijst (EML) 2023 - berekeningen_v1-4.xlsx)

Summary table: some estimated savings

Measure	Typical Savings (%)	Payback Period*	Sector Applicability/comments	Source
High-Efficiency Motors (IE3/IE4)	~2–10%	<2 years	All sectors; Savings are incremental, if the jump goes from IE1 to IE4 the savings potential is the higher percentage.	[28]
Variable Speed Drives (VSDs)	2-40%	<1–2 years	Pumps, fans, compressors; Depending on application and load profile	[5], [28], [31]
Waste Heat Recovery	5–50% but 20-30% most observed.	2–5 years	Steel, cement, chemicals; Strongly site-specific (depends on temperature level + load factor + degree of integration).	[7], [20], [25] [27], [28]
Insulation (pipes, tanks)	80-90%*	1-2 year	All sectors; *reduction heat loss for uninsulated components	[8], [28]
Energy Management Systems (EMS)	11-30%	1–3 years	All sectors	[28]
Predictive Maintenance	2–6%	1–2 years	Across industry, oil & gas, mining, and power plants; indirect savings, avoided downtime; AI-driven	[28]
Organic Rankine Cycle (ORC) power plants	3-5%	2-7 years	All sectors	[2],, [30], CE Delft,

* These savings and Payback period are derived and sometimes estimated from the information reported in the sources.

Special mention: ORC potential of the Netherlands

The Netherlands' industrial waste heat recovery potential forms part of the wider European opportunity, which the Knowledge Center on Organic Rankine Cycle technology (KCORC) conservatively estimates at around 150 TWh_{el} per year of CO_2-free electricity from currently untapped thermal energy across the EU. Harnessing this waste heat through Organic Rankine Cycle (ORC) technology can improve energy efficiency, avoid additional CO_2 emissions, and support both national and European decarbonisation objectives [26].

The estimated potential for ORC power plants in the Netherlands varies across industrial sectors. KCORC identifies approximately 11 MW_e in paper, 21 MW_e in primary steel, 667 MW_e in the chemical sector, 194 MW_e in food and beverages, and 20 MW_e in refineries, resulting in a total installable capacity of about 925 MW_e. Assuming 8,000 full-load hours per year, this corresponds to roughly 7.4 TWh_{el} (≈27 PJ) of electricity annually, showing the significant opportunity for energy recovery and emissions reduction in Dutch industry [26]. 7.4 TWh of electricity per year would avoid approximately 1.4 Mt CO_2 annually, assuming an average EU electricity emission intensity of 187 g CO_2e/kWh for 2024, [as reported by the European Environment Agency (EEA).]

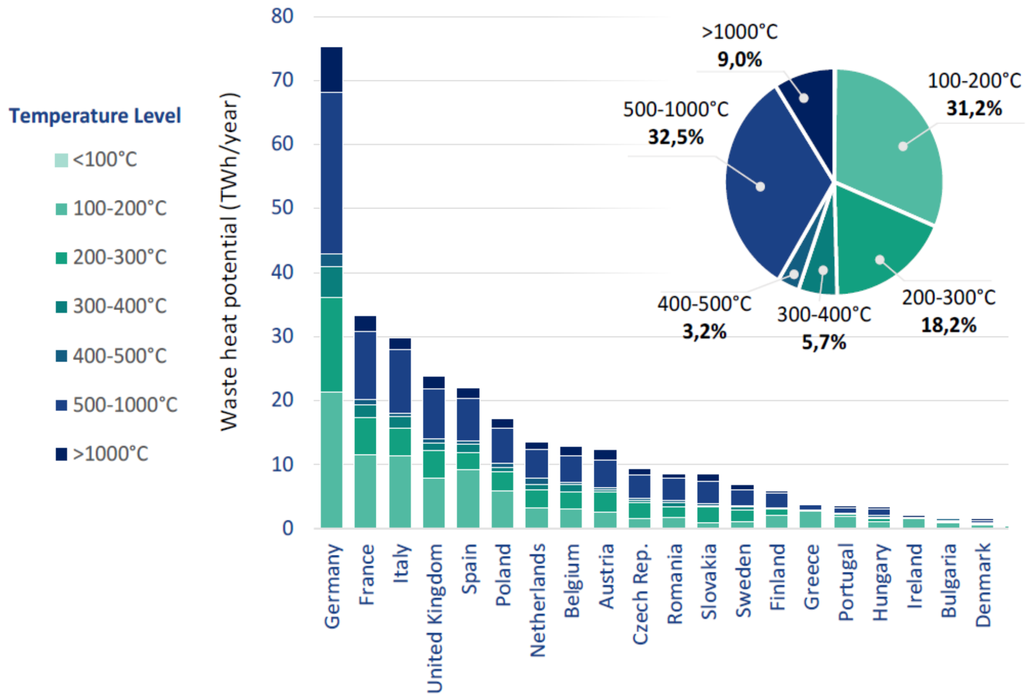


Figure 1. Distribution of waste heat recovery potential across Europe, with temperature levels of available, unused thermal energy [26]

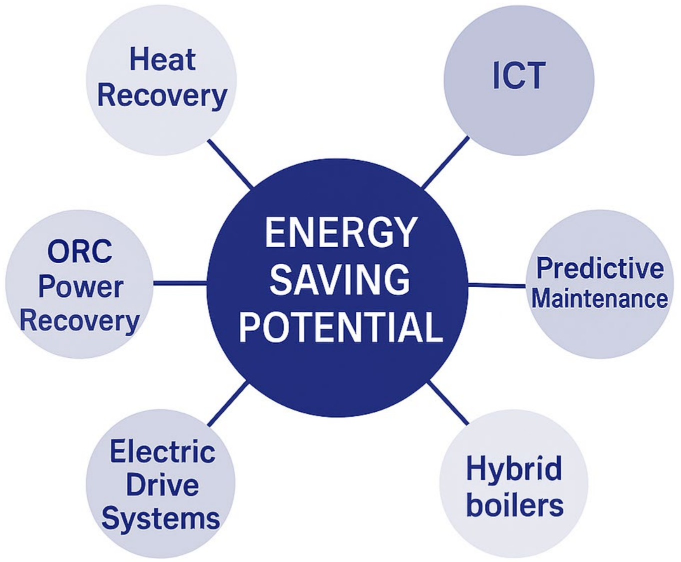
Key technologies: categories

Heat Recovery

Heat recovery offers substantial technical potential to reduce thermal energy losses in industrial processes. Given that thermal energy accounts for a large share of industrial energy demand, this potential is highly relevant for overall efficiency improvements System-level measures such as waste heat recovery, hot air recycling, flue-gas heat utilisation, and improved process integration can typically deliver energy savings on the order of 10–20%, with payback periods below five years [18, 25, 27].

Improved is identified as a low-cost, widely applicable measure, particularly for surfaces above approximately 60 °C, providing rapid reductions in heat losses and short payback times [8, 28]. When combined with heat recovery technologies, further enhances system-level performance by limiting avoidable losses [27].

Additionally, flare gas heat recovery addresses significant waste streams by recovering the energy content of gases that would otherwise be flared. with studies showing that up to approximately 87% of the flare gas heating value can be recovered through integration with existing refinery systems [10]. These solutions are mature and cost-effective, making them ideal for sectors with high heat demand.



Key technologies: categories

ICT (Information & Control Technologies)

ICT solutions focus on optimising motor and pump operations through frequency control, variable speed drives (VSD), and advanced analytics. Energy savings range from 20–50%, with some applications achieving up to 70% reduction in consumption. Predictive maintenance and process optimisation add 1–3% savings with quick payback. The total energy savings that could be realised by adopting VSDs across European industry are estimated to exceed 121 TWh per year, representing around 15% of overall industrial electricity consumption in the EU[28].

Fraunhofer [31] also reports, that VSDs can significantly reduce energy consumption in systems where the flow rate needs to be adjusted, such as pumps and fans. On an individual basis, the energy savings achieved by installing VSDs typically range from 10% to 75%, depending on the specific application and its operating conditions.

However, when considering the entire market, the average saving potential is reported lower, between 2% and 30%, because not all applications are suitable for VSDs and a considerable number of systems already have VSDs installed EU wide. This means that while VSDs offer substantial efficiency improvements, the overall impact is moderated by existing adoption

Maintenance

Preventive maintenance is a low-cost yet powerful strategy for energy efficiency. Actions such as leak detection in compressed air systems, thermographic inspections, and cleaning air coolers are reported to save 5–10% up until 40% of energy [28]. With that comes the application of AI, where IEA states that application of existing AI-led solutions to be equivalent to around 5% of energy-related emissions in 2035 [32]. All these measures would reduce energy waste and improve reliability and extend equipment life, making them essential for sustainable operations.

Key technologies: categories

Electric Drive Systems

Electric motor systems account for 46% of all electricity consumption in Europe, most of which is used in industrial applications such as pumps, fans and compressors. This makes motor systems a major lever for reducing industrial energy demand. Efficiency improvements can be achieved in two ways: upgrading the motor itself and improving how it is operated. Replacing older motors with high-efficiency models (e.g. IE3 to IE4) typically reduces losses by around 2–8%, depending on size and load profile. Larger savings (>15%) are possible when a broader range of upgrades is considered, including replacing very old motors, improving system design, or addressing oversizing [5, 28, 31].

These technologies deliver long-term reductions in energy costs and emissions. They are critical for industries seeking to cut electricity consumption and improve overall system performance.

Other Electrification

The IEA concludes that there is significant energy-saving potential in industry throughout Europe, primarily through efficiency improvements, electrification and digitalisation, and that this potential is essential but currently underutilised [29].

Advanced electrification technologies provide transformative potential for decarbonisation. Induction heating achieves >75% thermal efficiency, while Organic Rankine Cycle (ORC) systems could cut 1.4 Mt CO_2 annually Mt emissions. Hybrid boilers reduce standby energy losses by around 10%, offering flexibility in heat generation [26]. These solutions require higher capital investment and custom justification but deliver significant long-term benefits for large-scale industrial applications [2, 26]

Concluding words: estimated potential for non-electrification measures

The RVO report presents a technical saving potential of roughly 50 PJ/year, of which around 26 PJ/year relates to non-electrification categories such as steam systems, “other”, , cooling, baths, and part of drive systems (RVO breakdown: Process heat 22, Other 10.27, Steam 10, Drive systems 5.3, Process 2.3, Cooling ~0.93, Process baths 0.04 PJ). MIDDEN reports a total of 43 PJ/year technical potential using a conservative bottom-up approach based on known measures, which falls in a similar range once non-electrification options are isolated. P6-25 reports 87 PJ/year, supported by more optimistic assumptions about innovative technologies and broader sector coverage. Its substantially higher estimate suggests that RVO values are moderately conservative.

Some RVO categories appear conservative when compared with international benchmarks. Drive systems are assigned 5.3 PJ in the RVO breakdown, whereas several studies indicate that motor systems account for ~70 % of industrial electricity use and consistently rank among the highest saving potentials in EU-27 scenarios. Process- potential is assigned only 2.3 PJ in the RVO values, while other organisations (Eiif) reports substantially larger potentials, for example, 14 Mtoe per year for EU-27 industry if is upgraded to VDI 4610 energy class C, estimated to be 40PJ for the Netherlands.

Finally, the RVO “Other” category (10.27 PJ) lacks a breakdown of included measures. This study identified technologies not explicitly covered, such as Organic Rankine Cycle (Slide 18), flare-gas heat recovery (Slide 14), advanced process control and AI-driven optimisation (Slide 15), and predictive maintenance (Slide 16). Literature and case studies show that these can deliver meaningful savings, reinforcing the conclusion that the RVO estimate, while broadly realistic, is likely conservative in several areas.

Concluding words

This was more of a general study; we identified several interesting technologies in the RVO report and connected them to literature to read to gain an understanding of their potential for the Dutch industry. It is not an in-depth literature review of the entire literature list. The RVO report reflects what companies are currently reporting, whereas the studies we reviewed focus more on technical potential and capabilities, which does not always align with what is realistically achievable in terms of investment and payback. The total energy-saving potential is broadly similar to the MIDDEN report, with the main differences appearing in the food sector and in how the sectors are aggregated. However, the specifics cannot be easily extracted from the report, which limits its reliability. For this reason, we recommend that the report be more transparent about its methodology and the type of information included. While we understand that RVO is bound by industry confidentiality, providing clarity on aspects such as the approach taken and which technologies are linked to which sectors would greatly improve readability and usefulness.

Additionally, although the RVO report highlights several promising technologies, it omits others such as flare gas heat recovery, AI in process industries, ORC, and induction heating. These technologies may currently have a low TRL but could become significant in the future.

Limitations and Next possible step:

Many of the reported values are Europe-centric and not specific to the Dutch sector. Within the way the study was set up, it was not feasible to explore the detailed applications for the Dutch industry, as it is not straightforward to determine what has already been implemented through literature and where further opportunities exist.

Future work could include interviews with industry stakeholders to map existing applications and conduct techno-economic studies specific for Dutch sectors with high savings potential, incorporating payback-period calculations and sensitivity analyses.

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