

VIBE

Navigator



Oils and fats industry



Revision log

Version	Date	Description
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The content of the VIBE Navigator, Calculator and Catalog has been compiled with care, based on the knowledge and information available at the time of publication. The recommendations and guidelines in this VIBE Toolkit are intended as a reference and guidance tool. No rights can be derived from the published information. VIBE and FME accept no liability for any damages resulting from the use of, or decisions based on, the content of this Toolkit.

Preface VEMW & FME

Dutch industry is an important pillar of our economy, employment and prosperity. Those contributions cannot be taken for granted, certainly not in the current climate of significant societal changes and challenges. It is precisely for this reason that it is very important that our industry today remains internationally competitive, innovative and attractive for investment. Energy saving plays a crucial role in this. Companies that succeed in structurally reducing their energy consumption not only strengthen their resilience, but also their innovative strength, productivity and attractiveness as an investment location.

Based on this conviction, FME and VEMW have developed the VIBE-2030 programme: Acceleration of Industrial Energy Savings towards 2030. We believe that energy saving is not just a climate measure, but a strategic precondition for a strong and future-proof industry. An industry that is less dependent on external energy sources, uses scarce resources more efficiently and is better able to respond to the economic and social developments of tomorrow. And with a concrete course of action!

With the support of the Ministry of Economic Affairs, we have expressed the ambition to support more than a thousand of the largest industrial business locations in the Netherlands within five years to achieve significant energy savings. We do this not by restating why energy saving is important, but by providing practical support to help companies determine how they can take action.

This toolkit is a first concrete result of that. It combines knowledge, practical experience and proven approaches that have been specifically developed for companies within the Dutch industry. The aim is to help organisations recognise opportunities more quickly, better inform investment decisions and accelerate successful implementation of energy-saving measures.

The task we face is extensive, but so are the benefits. Lower energy costs, more flexibility in the energy system, less extra pressure on the electricity grid, reduction of CO₂ emissions and a stronger competitive position go hand in hand. By focusing on energy saving, we are not only working on sustainability, but also on the earning capacity of the Netherlands.

I invite you to use this toolkit actively within your organisation and to take the next step with us. Only by sharing knowledge and acting can we achieve the ambition of VIBE-2030: an energy-efficient industry as the foundation for a strong, sustainable and competitive Dutch economy.

Hans Grünfeld
Director VEMW

Marco Workel
Director FME

Preface MVO

Energy is a significant cost for MVO members and an important sustainability consideration. Improving energy efficiency is an essential first step towards reducing costs and achieving climate neutrality. At the same time, geopolitical developments and volatile energy markets make effective energy management increasingly important for companies seeking to remain competitive.

MVO, the Netherlands Oils and Fats Industry, supports its members in reducing energy consumption and associated greenhouse gas emissions. Many of our members participated in the Long-Term Agreements on energy efficiency, which helped the sector improve its energy efficiency by 54% over the past three decades.

MVO welcomes the findings of the VIBE Navigator, which demonstrates that recently developed technologies offer further opportunities to reduce energy consumption between now and 2030. The VIBE project focuses on some of the most energy-intensive processes in our industry: oilseed crushing, vegetable oil refining and biodiesel production (FAME).

The VIBE Navigator presents the five most promising measures for each process, based on a representative production facility. The VIBE Calculator provides an indication of the potential energy and cost savings, while the VIBE Catalogue offers an overview of technology suppliers and practical examples of implementation.

I hope that companies throughout the vegetable and animal oils and fats industry will use the VIBE Navigator, Catalogue and Calculator to assess which measures can help them reduce energy consumption and costs while further lowering their greenhouse gas emissions.

I strongly encourage companies to explore these opportunities. At the same time, MVO is keen to understand the barriers companies may encounter when implementing these measures, whether technical, financial or institutional.

As an industry association, MVO is committed to working with its members and other stakeholders to overcome these challenges and further strengthen the energy efficiency, competitiveness and sustainability of our sector.

Frans Claassen
Managing Director, MVO

Frank Bergmans
Manager sustainable development, MVO

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General introduction



The VIBE Toolkit at a glance

The VIBE Toolkit helps you to **identify significant energy savings in your factory – the first step towards realisation**. Not a generic list with many small measures, but a practical selection of measures that can make the difference in the energy consumption of your production process.

The Toolkit consists of three parts to be used in conjunction:

1. Navigator – overview & direction

The VIBE Navigator is this document. Here you will find the selected reference plants, the corresponding mass and energy balances, the energy intensive unit operations and the five most promising energy-saving measures. For each measure, you will, in addition to the energy saving potential, gain insight into:

- How the technology works
- Potential grant and funding opportunities
- The indicative investment costs
- Impact on permits and grid congestion

This information will provide clear direction to quickly determine which measures may be interesting to investigate in more detail for your factory.

2. Calculator – translate the measure to your factory

There are no identical factories. With the VIBE Calculator Excel tool you can therefore adjust the key figures from the Navigator to your own situation: Capacity, investment costs, savings, subsidies, energy prices, etc. This allows you to evaluate and compare measures.

3. Catalog – practical examples

An energy-saving measure comes to life when you can see where it has been applied already. The VIBE Catalog collects examples from practice of companies that have already implemented one or more of the Top-five measures (or comparable energy-saving measures). This information helps you to find parties and practical experience that will aid you in making your choices.

The three components complement each other:

- **Navigator** → What are the most promising measures for my type of factory?
- **Calculator** → What could these measures mean for my factory?
- **Catalog** → Where has this already been implemented and what can I learn from it?

The VIBE Toolkit does not make the investment decision for you. It does help you to speed up your decision-making process: **which possibilities are serious enough to investigate further**.

Freely available and up to date

The VIBE Toolkit is **publicly available and free of charge**. So, you don't have to be a member of a trade association to get started. You can register yourself at <https://vibe2030.nl/bedrijf/> to receive the latest updates about the developments and implementation of the VIBE Toolkit.

Moreover, the Toolkit continues to be developed. New insights, practical examples, subsidies and relevant developments can be incorporated into subsequent versions. Therefore, for the **most up-to-date version of the Navigator, Calculator and Catalog**, please visit www.vibe2030.nl.

Developed and tested with industry

This VIBE Toolkit has been developed for the industry, together with industry **and other expert parties**. Companies from the Oils and Fats business reviewed the reference plants, possible energy-saving measures and the final Top 5. In addition, specialists in the field of subsidies, financing and permits have contributed their expertise.

The figure below shows which parties were involved in the development of this Toolkit. You **can find more information, including who is involved in the wider VIBE programme**, in Appendix A A. Creation of this toolkit.



The **VIBE team** has developed the VIBE approach and ensures the quality and consistency of the VIBE Toolkits for various industrial sectors. To this end, it seeks collaboration with **industry associations** to engage companies within the sector and ensure that the approach aligns with real-world practice. The technical content of the Toolkit was developed by a **toolkit developer** (technical consultant) who was selected through an open procedure. This selection is based, among other things, on its knowledge of the industry. Subsequently, a **Toolkit Sounding Board** was established, comprising companies that validated the analyses, proposed measures, and technical details against real-world practice. Finally, the VIBE team has been compiling external input from expert parties who have contributed knowledge on specific non-technical aspects: subsidies, financing, and permits

VIBE focus

Energy saving inside the fences of the factory

VIBE consciously chooses the **factory as the starting point**. We primarily look for energy saving measures within the fences of the factory and therefore as much as possible within the sphere of influence of the company itself. This allows companies to decide for themselves which measures are interesting to investigate further and when they want to get started.

VIBE focuses on measures that reduce the final consumption of energy.

Focus on the high impact

Many well-known, generic measures exist that companies can apply to save energy, like LED lighting or replacing diesel propulsion with electric motors. Many of these measures are well described in, among other things, the “basislijst energiebesparende maatregelen” and the “Erkende Maatregelen Lijst” (EML) and are part of the Dutch legal energy-saving obligations.

VIBE adds something new. We are looking for the **larger, often process-integrated steps** that can contribute substantially to reducing the energy consumption of the entire factory. These measures might intervene in the primary production process or in the way in which energy is utilised and recovered within that process.

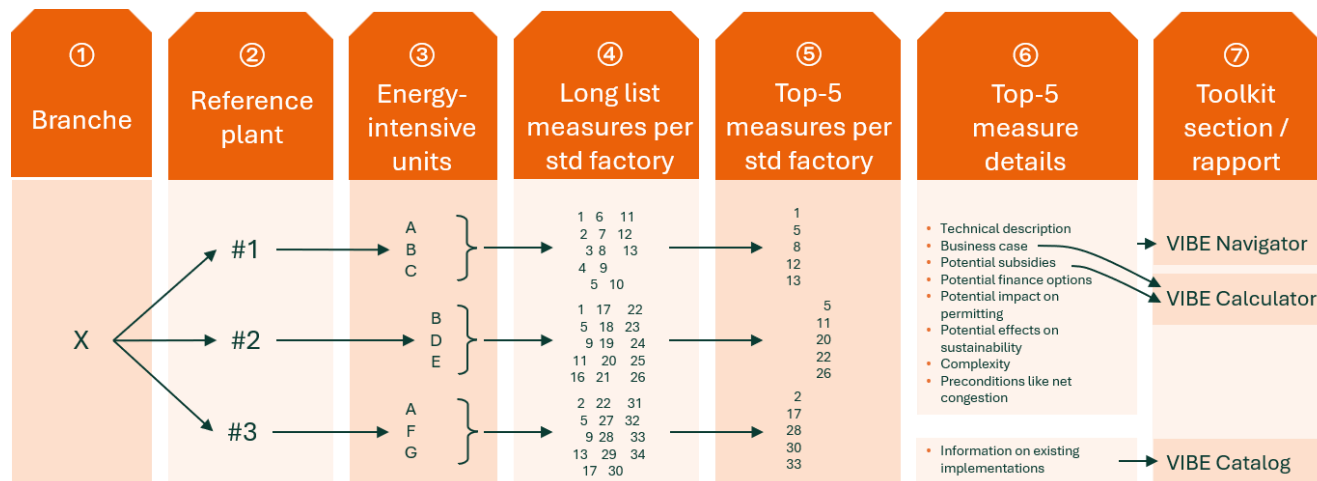
Market-ready technology

VIBE focuses on TRL-8/9 technologies, making that the top-five measures **can be implemented before 2030**. Promising technologies, encountered during the development of the Toolkit (TRL 7), have been listed on the 'watchlist' per Reference Plant.

This demarcation emphatically does not mean that solutions outside the VIBE focus are not interesting. Energy monitoring, in-house energy generation, energy exchange with surrounding companies and other sustainability routes can also be relevant for your company. They just answer a different question than the one that is central to this Toolkit.

From energy analysis to Top-5

How do you get from a very diverse industry with different production processes to a limited number of measures that may be relevant to many companies? VIBE uses a fixed approach for this. We don't start with a technology or solution, but with the **factory and the energy consumption**. From there, we will work step by step towards a Top 5 of promising energy-saving measures.



1-2. Translating the Industry Sector to Reference Plants

Production processes and energy profiles can differ greatly within a single industry sector. That is why we first define a limited number of **reference plants**: recognisable, energetically clearly different production processes that occur at several companies within the industry sector.

A reference plant is not a copy of an existing company, but a simplified and representative model. This allows us to discuss and calculate processes, energy consumption and measures without using company-specific or competition-sensitive information. At the same time, a common basis is created from which companies can compare their own situation.

3. First understand where the energy is consumed

We then carry out an energy analysis for each reference plant. Where is the most energy used? Where do losses occur? At what temperature levels is the energy consumed and is residual heat available? Where is the greatest technical potential to save energy?

That analysis determines where we then look for solutions. In this way, we avoid starting with a preferred technology and then trying to find an application for it.

4-5. From a broad search to a Top-5

For the most important energy-intensive process steps, we first draw up a broad **longlist of possible measures**. From these, we then select the five measures for each reference plant that offer the best prospects within the VIBE focus. This selection is driven by a combination of:

- **Significant energy savings** at the level of the total factory
- **Economic feasibility**, possibly with the help of subsidies
- **Technical maturity**; in principle, we are only looking at TRL8-9, which can therefore be implemented before 2030
- **Suitability within the Dutch energy infrastructure**, including limitations due to grid congestion

Measures that do not make it into the Top 5 do not automatically disappear from the picture. Interesting solutions can appear in the longlist or, if the technology is not yet sufficiently mature, on the **VIBE Watchlist**. Both can be found in the appendices.

6-7. From Top-5 to practical Toolkit

We will then further develop the selected measures. In doing so, we not only look at the technology and the possible energy savings, but also at what is needed to get from an interesting solution to an actual project:

- **Technical details:** what technical changes are required in the installation
- **The business case:** CAPEX estimate and savings
- **Potential subsidy opportunities.** If a subsidy is deemed possible for a specific measure, see Appendix B. Relevant RVO subsid for more information about that subsidy opportunity. Be sure to take advantage of the opportunity to have your specific situation assessed by the RVO
- **Potential financing structures:** equity, balance sheet financing, leasing, project financing, and external ownership with operation (ESCO) may be applicable
- **Potential impact on permits:** the various environmental aspects are assessed, and the potential consequences for the environmental permit are then evaluated. Be sure to use the online permit check in the Omgevingsloket to have your specific situation assessed
- **Potential sustainability impacts:** in addition to Scope 1 and 2 impacts, other potential impacts are also considered, such as water and NOx
- **Complexity:** How complex is the solution? Can it be (easily) retrofitted into an existing plant?
- **Constraints** such as grid congestion are also considered
- **Information on existing implementations:** Where has this technical solution already been implemented, and who was involved?

If there is a logical order for implementing the measures, this is described in the paragraph "example roadmap to implementation".

This information eventually comes together in the three parts of the **VIBE Toolkit: Navigator, Calculator and Catalog**.

How to use the VIBE Toolkit

The VIBE Toolkit is intended to quickly take you from an initial understanding of the greatest energy-saving opportunities to a **substantiated next step**. The Navigator, Calculator and Catalog complement each other. Therefore, it is preferable to use them in conjunction.

From opportunity to next step in five steps

1. **Recognise your production process. Find the reference plant that best suits your production process and energy consumption.**
2. **Explore the biggest savings opportunities. In the VIBE Navigator, you can find out the Top 5 measures for this reference plant and read how the measures work technically, where the savings come from and which preconditions are important.**
3. **Translate the key figures to your situation. Use the VIBE Calculator** to adapt the key figures and business case to your factory. Consider, for example, capacity, energy consumption, energy prices, investment costs and possible subsidies.
4. **Learn from existing projects. Check the VIBE Catalog** to see where one or more measures have already been applied and which companies, technology suppliers and other parties were involved.
5. **Create an action plan**
Translate the promising measures into a coherent implementation plan with priorities, responsibilities, resources and decision points.

Use the information about **subsidies, financing structures and permits** to take an appealing measure further towards a concrete project.

The actual translation of a measure to your factory remains **tailor-made**. If you do not have the necessary technical or economic expertise in-house, involve an expert party in good time to further develop the measure and determine the feasibility for your specific situation. As soon as you have a concept plan, contact RVO to discuss potential subsidies, and contact the Omgevingsdienst to discuss potential impact on your permit situation.

Always work with the most up-to-date information

Technology and real-world experience continue to evolve. The same applies to **subsidies, financing options, laws and regulations and permit requirements**. Information that was up to date at the time of publication may therefore have changed.

The VIBE team will periodically update the Toolkits with new insights and available information. Therefore, before proceeding with any measure, always check whether a newer version is available at www.vibe2030.nl.

In short: use the Toolkit to recognise opportunities, accelerate choices and take the next step in a targeted way to save significant energy.

Which reference plant suits your plant?

The Dutch Oils and Fats industry is very diverse. The industry includes not only producers, but also traders and logistics companies. For VIBE we specifically looked for the companies and production processes where **significant energy savings can be achieved at factory level**.

From industry to three recognisable processes

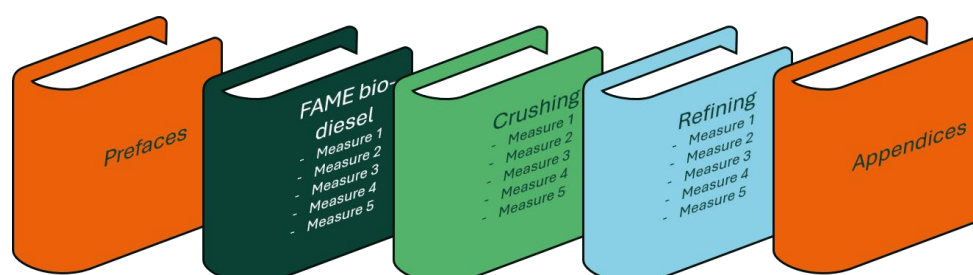
As a first step, we looked at the more energy-intensive companies within the industry. The energy-saving research obligation was used as an important indicator. Subsequently, it was investigated which production processes at these companies are sufficiently similar in terms of energy to be able to translate them into a joint reference plant.

This resulted in three reference plants:

1. **FAME/biodiesel**, representing the conversion of oils and fats into biodiesel through esterification, transesterification, phase separation, methanol recovery and polishing.
2. **Crushing**, representing soybean preparation, hexane extraction, solvent recovery and meal treatment in a DTDC system.
3. **Refining**, representing the purification and conditioning of oils through process steps such as degumming, neutralisation, washing, drying, bleaching and deodorisation.

These three processes clearly differ in the way energy is used. At the same time, they are each used by several companies in the Netherlands and together represent a significant proportion of energy use within the industry. In this way, they provide a sufficient basis for carrying out a recognisable energy analysis for each reference plant and arriving at a relevant Top 5 of energy-saving measures.

A reference plant is emphatically not an exact copy of one existing company. It is a **representative model of a production process**, on which energy consumption, losses and possible measures can be projected. A separate section has been created for each of these reference plants, containing everyone's top-five solutions. The structure of this Toolkit is therefore as follows:



Not every process fits in a reference plant

The choice of these three reference plants does not mean that other parts of the industry do not have interesting opportunities for energy savings. For some processes, however, it turned out not to be possible to arrive at a sufficiently representative reference plant and joint Top-5 within this approach. This applies, for example, to the **margarine industry**.

Does your production process not fit well within one of the three reference plants? Then the measures described can still offer interesting starting points, but the translation to your own factory requires more customisation.

Background of the information provided for the reference plants and measures

Based on the process balance, heat demand, utility usage and operating hours of each reference plant, Bilfinger determined an indicative energy saving for each measure. These savings were calculated or estimated against the energy use of the relevant reference plant, so that measures can be compared on a consistent basis.

The payback period was subsequently estimated based on:

- Bilfinger expert judgement regarding technical feasibility, technology readiness level, implementation risk and high-level CAPEX intensity.
- Brownfield factors for complex equipment and retrofits, such as MVR systems, heat pumps, vacuum systems, DTDC modifications, solvent recovery integration and heat recovery systems.
- Energy consumption and avoided utility costs, considering additional electricity consumption for electrification, heat pumps or MVR.
- Indicative energy-saving potential, which can be assessed more reliably at this stage than detailed CAPEX and full business-case performance.

The results are intended for screening and prioritisation. They provide a structured basis for comparing measures, identifying the most promising options and selecting measures for further feasibility assessment. The results should not be interpreted as final investment-grade engineering calculations. An important limitation is that several measures may overlap. For example, a heat pump measure, an MVR measure and a heat recovery measure may use the same waste heat source or reduce the same steam demand. For that reason, the savings are not additive without further process integration analysis. In the next project phase, selected measures should be validated with site-specific data, supplier input, utility balances and a detailed heat source and heat sink assessment.

Reference plant #1:

FAME biodiesel

Summary

A standard biodiesel factory is defined based on the FAME process, using vegetable oil as input. Biodiesel is produced through several steps using acids, bases and methanol, with glycerol as a by-product.

The main energy-intensive operations are the biodiesel polishing column and distillation steps separating glycerol, methanol, water and biodiesel. Four of the top five measures apply MVR in distillation; the fifth uses a heat pump in the polishing column. Expected payback is 5-10 years.

MVR in distillation is proven and increasingly used by different suppliers. The polishing column requires a temperature lift of about 100 C, for which several heat pump/MVR solutions are available.

Applying MVR to distillation can save about 35% energy, while a heat pump on the polishing column can reduce consumption by another 25%. Together, these measures can save up to 60% on energy, depending on existing heat integration.

All top five measures have good subsidy options and are expected to require only limited permit adjustments. As all five measures are process-integrated, they are generally less suitable for Esco or operational lease financing.



Description reference plant

Production process

The FAME block flow diagram below provides a simplified overview of the standard FAME/biodiesel production route used in this analysis. It shows how used oils and fats are converted into biodiesel through a sequence of feedstock preparation, esterification and transesterification, phase separation, methanol recovery and final FAME polishing. The diagram is used as the reference for identifying the main unit operations and for linking these process steps to the energy balance of the reference plant.

The reference plant has been developed to produce biodiesel based on the FAME (Fatty Acid Methyl Esters) process. There are also other biodiesel production routes, such as HVO (hydrotreated vegetable oil) and HEFA (hydroprocessed esters and fatty acids); these are not discussed in this document.

The energy analysis shows that the reaction steps themselves are not the dominant energy users.

Most of the energy demand occurs downstream, where methanol must be recovered, glycerol and methanol are separated, and the FAME/Biodiesel product is polished to meet final quality requirements. These steps require reboiler heat, condensation and in some cases vacuum operation, which makes them the most relevant areas for energy saving measures like heat integration, mechanical vapour recompression (MVR), high-temperature heat pumps and improved vacuum systems.

Capacity reference plant

Parameter	Value	Unit
FAME production capacity	100,000	tonnes/year
Running hours	8,000	hours/year
UCO feedstock	97,078	tonnes/year
Methanol usage	10,643	tonnes/year
Glycerol production	8,073	tonnes/year

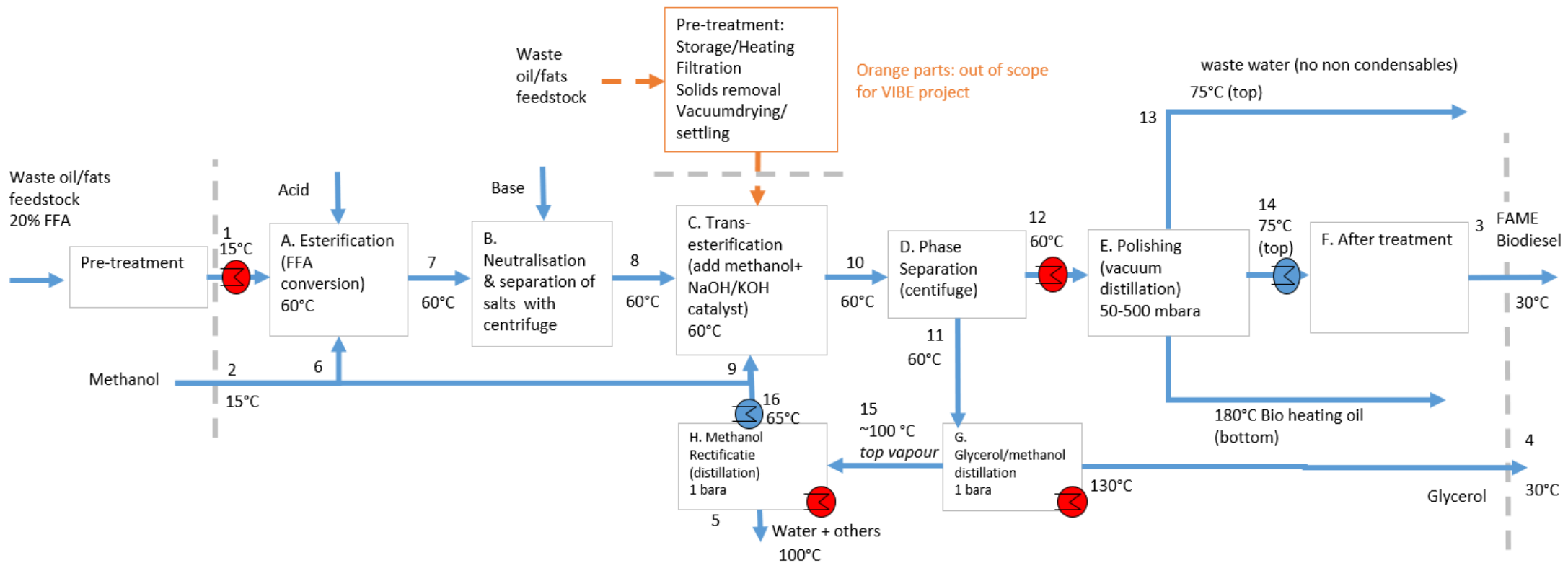
Unit operations

Unit operation	Function	Relevance for energy analysis
Esterification	Conversion of FFA with methanol	Limited direct heat demand; exothermic effect not included in the energy balance
Transesterification	Conversion of triglycerides to FAME and glycerol	Reaction step around 60°C; downstream separation determines energy demand
Centrifugal phase separation	Separation of FAME and glycerol phases	Electrical power approximately 13.3 kWe
Glycerol/methanol distillation	Separation of methanol/glycerol/water	Reboiler duty circa 1.90 MW
Methanol rectification	Methanol purification/recovery	Reboiler duty approximately 0.80 MW; condenser approximately 2.00 MW
FAME-polishing	Vacuum distillation for product quality	Reboiler duty approximately 2.60 MW; steam ejector approximately 0.205 MW

Reference Plant FAME production

The FAME/biodiesel process consists of a sequence of feedstock preparation, reaction, separation and product-finishing steps. The used oils and fats are first conditioned to remove solids, water and other impurities before they are converted with methanol into FAME and glycerol. After conversion, the product mixture is separated into FAME-rich and glycerol-rich phases, followed by methanol recovery and final FAME polishing. From an energy perspective, the focus is on the downstream separation and polishing steps, where distillation, vacuum operation and methanol recovery create the largest heat demand.

- A. Esterification: conversion of free fatty acids with methanol, using acid as a catalyst.
- B. Neutralisation and Salt Separation: conditioning of the reaction mixture and removal of salts.
- C. Transesterification: conversion of triglycerides with methanol and an alkali catalyst (NaOH or KOH) to FAME and glycerol.
- D. Phase Separation: separation of FAME-rich and glycerol-rich phases, in the standard case using centrifuges.
- E. FAME Polishing: vacuum distillation to achieve FAME product quality.
- G & H. Solvent Recovery: methanol recovery and glycerol/methanol separation via distillation.



Process variation

In existing plants, feedstock quality, FFA content, methanol excess, catalyst, column pressures, vacuum system and heat integration may differ. These variations partly determine the applicability of MVR, membranes, heat pumps and alternative vacuum systems.

Mass and energy balance

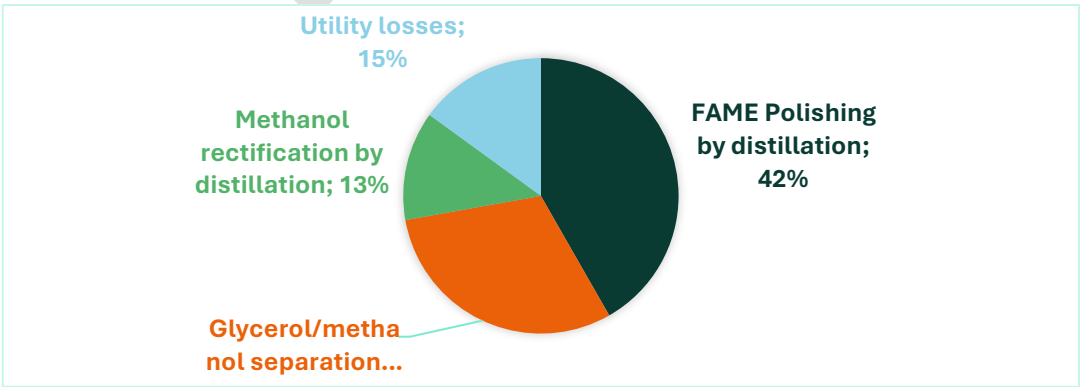
Energy / utility	Value	Unit	Remark
FAME polishing reboiler	2.60	MW	0.75 GJ/ton FAME
Glycerol/methanol reboiler	1.90	MW	0.55 GJ/ton FAME
Methanol rectification reboiler	0.80	MW	0.23 GJ/ton FAME
Utility losses	0.94	MW	Included in total heat demand
Total heat demand	6.24	MW	49,921 MWh/a (excluding electrical use)
FAME polishing condenser	2.60	MW	Estimated based on reboiler load
Methanol rectification condenser	2.00	MW	Estimated based on reboiler load
Total condenser cooling	4.60	MW	

Energy analysis

The figure below presents the heat balance of the FAME/biodiesel reference plant. It visualises the main heat consumers and shows how the annual gas consumption of 5,678,282 Nm³/year is distributed across the relevant process steps. The electricity consumption is estimated separately at approximately 10% of the total factory energy consumption. Because the figure focuses on heat demand only, this electricity consumption is not depicted in the graph. The balance is based on 8,000 operating hours per year and an annual production volume of 100,000 tonnes of FAME/biodiesel.

The largest heat users shown are the FAME polishing reboiler, the glycerol/methanol distillation reboiler and the methanol rectification reboiler. These steam-driven separation and polishing steps dominate the heat demand shown in the figure and therefore form the primary focus for energy-saving measures.

At the same time, the figure also shows that cooling demand is present in the condenser systems. Direct electrical demand is estimated separately at approximately 10% of total factory energy consumption and is not depicted in the graph. This combination of simultaneous heating and cooling demand makes the FAME/biodiesel process particularly relevant for heat integration, mechanical vapour recompression, high-temperature heat pumps and improved vacuum-system concepts.



Top 5 measures

The top five were selected following a review of the longlist against the FAME/biodiesel reference plant. The selection was not based on indicative energy saving alone. Measures were prioritised where they address a clearly present energy user in the reference plant, have a realistic route to implementation before 2030, can be applied in existing brownfield FAME/biodiesel plants, and offer a sufficiently concrete basis for further technical and business-case development. Measures with limited energy impact, high uncertainty, limited proof in this specific application, or strong dependency on site-specific product quality and process constraints were kept as watchlist or site-specific measures.

Based on this approach, the selected FAME/biodiesel measures focus mainly on the dominant thermal separation steps: methanol recovery, glycerol/methanol separation and FAME polishing. These steps represent the largest heat users in the reference plant and provide the strongest opportunities for heat upgrading, vapour recompression and reduced steam demand. The selected measures therefore focus on MVR concepts, high-temperature heat pumps, direct vapour recompression and improved vacuum generation. Final feasibility should still be confirmed with site-specific heat and mass balances, column operating data, vapour composition, ATEX assessment, electricity availability, supplier input and retrofit assessments.

It should be noted that measures 1 to 4 overlap and should not be combined in the reference plant assessment. Measures 1 and 4 both relate to the methanol and glycerol recovery section and address the same part of the column system through alternative heat-recovery and vapour-recompression concepts. Measures 2 and 3 also target the same part of the glycerol/methanol distillation column and should be considered as alternative MVR concepts. For this reason, the indicative savings of measures 1, 2, 3 and 4 are not additive and these measures should be assessed as mutually exclusive options during the selection stage. Measure 5 is a separate measure in the reference plant, as it focuses on the FAME polishing column rather than the methanol and glycerol recovery section.

#	Measure	Indicative saving	Relative to reference plant	Indicative payback	Selection rationale
M1	Two-stage MVR on the methanol rectification and glycerol/methanol distillation columns	19,406 MWh/a	35%	5-10 years	Highest saving potential in the longlist and directly targets the dominant methanol and glycerol recovery reboiler duties. The measure uses vapour recompression to reduce external steam demand in the core thermal separation section of the reference plant.
M2	Top-vapour recompression with direct bottom injection in the glycerol/methanol distillation column	5,300 MWh/a	~10%	5-10 years	Closely linked to the same dominant distillation duties and offers a strong heat-integration route by compressing top vapours and reusing the latent heat directly in the column. Selected because of its high theoretical saving and clear relevance for methanol recovery.
M3	One-stage MVR using process vapours to heat the glycerol/methanol distillation reboiler	5,600 MWh/a	~10%	5-10 years	Relevant MVR variant with a slightly lower saving than the two-stage concept, but potentially simpler depending on column pressure levels, achievable temperature lift and integration with existing reboilers. Selected as a practical alternative concept for further screening.
M4	Vacuum steam production from the methanol/glycerol recovery condenser combined with MVR	17,270 MWh/a	31%	5-10 years	Uses condenser heat more actively by producing low-pressure or vacuum steam and upgrading it with MVR. Selected because it addresses the simultaneous heating and cooling demand in the methanol and glycerol recovery section, although feasibility depends strongly on temperature levels and heat-source quality.
M5	High-temperature heat pump or MVR on FAME polishing column	15,100 MWh/a	27%	5-10 years	Targets the FAME polishing reboiler, one of the largest individual heat users in the reference plant. Selected because it reduces steam demand in the product-finishing section and uses available condenser or vapour heat, but requires careful assessment of vacuum operation, product quality, ATEX requirements and retrofit constraints.

FAME Biodiesel

Measure 1: Two-stage MVR on the methanol rectification and glycerol/methanol distillation columns

Summary

This measure uses condenser or top-vapour heat from the methanol and glycerol recovery section to produce low-pressure or vacuum steam. By upgrading this recovered heat with an MVR, a significant part of the reboiler duty can be supplied. This reduces steam demand and improves heat integration in the solvent recovery section of the FAME/biodiesel process. Key attention points are heat-source temperature, vacuum-steam quality, temperature lift, compressor selection, ATEX requirements, electrical capacity and brownfield integration.



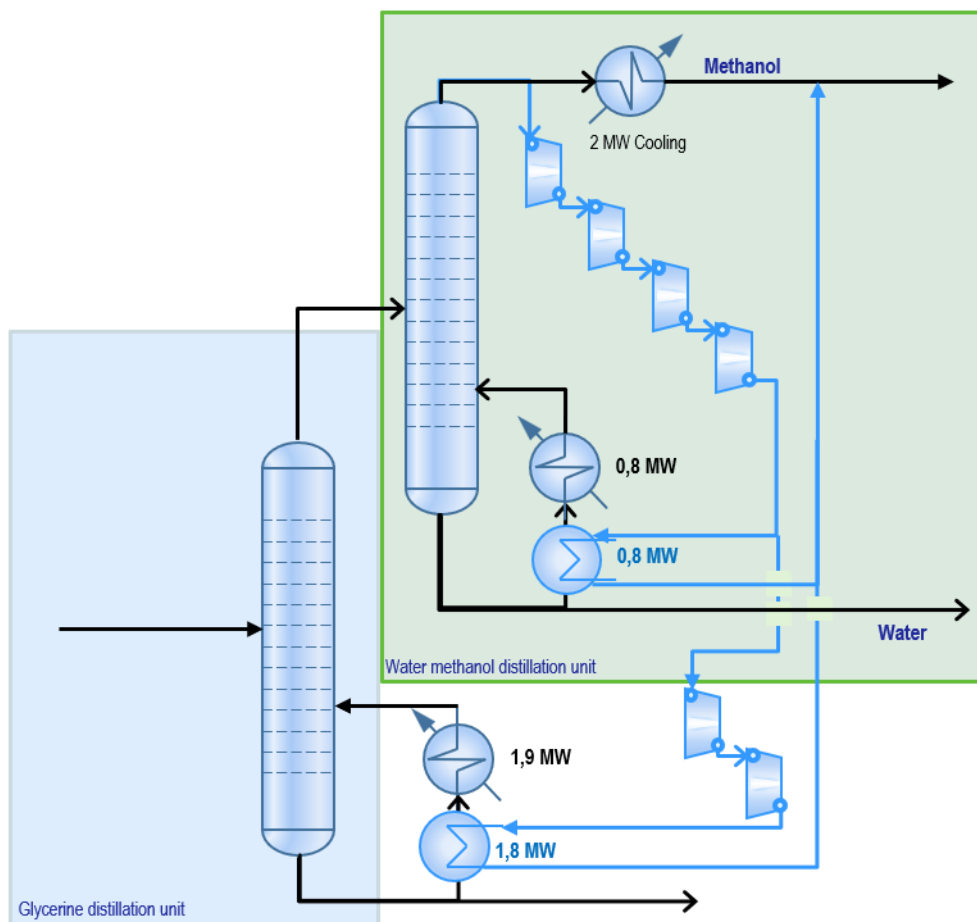
Technical description

Existing process (Black arrows)

A mixture of glycerine, water and methanol is separated in a set of two distillation columns. The first column is heated with a reboiler at 130°C and 1.9 MW thermal load. The second column is heated with a reboiler at 100°C and 0.8 MW thermal load. Both columns are atmospheric.

New process (blue)

A four to five-stage MVR system will compress the methanol vapour to 4.8 bara (110°C). A part of this vapour stream is used to heat the second-stage reboiler. The remaining vapour is compressed to 10.9 bara (140°C) with two compressor stages to heat the glycerine reboiler at a duty of 1.8 MW. Only 0.1 MW of steam demand remains of the 2.7 MW total steam demand. Methanol is injected with a spray at the inlet of the compressors to cool the gas during compression. The COP is 4.18.



Key numbers

Energy consumption		Relative	Annual
Change in natural gas	-3.04 MW	-49%	-24,352 MWh/a
Change in electricity	+0.62 MW		+4,947 MWh/a
Total change in energy	-2.42 MW	-35%	-19,406 MWh/a
CO ₂ emissions Scope 1			-4,927 ton/a

The change in natural gas is calculated based on the reduction of steam demand

CAPEX	Remark
Main equipment (compressors & reboilers)	1,420 kEUR
Lang factor	5
Total CAPEX estimate	8,000 kEUR

The CAPEX estimate is based on the main MVR equipment package, including multi-stage methanol vapour compression, reboiler integration, heat exchangers, piping, controls and associated electrical infrastructure. The Lang factor reflects brownfield installation complexity, including tie-ins, ATEX requirements, instrumentation, insulation, structural supports and commissioning. The estimate should be considered a screening-level value and needs to be refined with vendor quotations, plot-space assessment and a shutdown/tie-in plan.

Factors for implementation

Congestion

The measure increases electrical demand by approximately 0.62 MW for the compressor system. This additional load may be limiting on sites with limited grid capacity or internal transformer constraints. Before implementation, the available electrical connection, transformer capacity, MCC capacity and cable routing should be checked. In case of grid congestion constraints, implementation may require load management, phased operation, local generation or reinforcement of the electrical infrastructure.

Retrofitting

Retrofitting is expected to be moderately complex because the MVR system must be integrated directly with two operating distillation columns. Main retrofit items include compressor placement, methanol vapour piping, tie-ins to the existing reboilers, controls, safety instrumentation, ATEX zoning, condensate handling and access for maintenance. Installation (final tie-in) should preferably be planned during a scheduled shutdown, with temporary provisions assessed if continuous production must be maintained.

Sustainability and other emissions

Water: no significant direct change is expected compared with the current steam-driven configuration. Indirectly, the lower cooling duty may reduce cooling-water circulation or cooling-tower load, depending on the existing utility configuration.

Natural gas: the measure reduces natural gas consumption by approximately 24,352 MWh/a, corresponding to a 49% reduction compared with the reference plant heat demand. NO_x: the gas-fired boiler will consume less fuel due to the reduced steam demand. As a result, NO_x emissions are expected to decrease. The indicative reduction should be calculated from the actual boiler emission factor and operating profile; a preliminary estimate is approximately 170 kg NO_x/year.

Technical maturity

Mechanical vapour recompression is a proven industrial technology for evaporation and distillation applications, including solvent and alcohol recovery. The specific application to methanol-rich vapours in a brownfield FAME/biodiesel plant is technically feasible but requires case-specific engineering. The maturity is therefore assessed as commercially available technology with medium implementation risk, mainly related to compressor selection, process control, ATEX compliance, fouling, turndown behaviour and integration with the existing columns.

Possible suppliers

Potential suppliers and engineering partners include GEA, Sulzer, Alfa Laval, Atlas Copco, Howden/Chart, Piller, Everllence and Busch/Pfeiffer for vacuum-related equipment. Final supplier selection should be based on methanol vapour compatibility, ATEX design, compressor efficiency, temperature lift, turndown range, maintainability and reference cases in solvent recovery or distillation.

Recommendations

Proceed with a site-specific feasibility study focusing on process integration, compressor concept selection, ATEX zoning, electrical capacity, acoustic impact and vendor validation. The next step should include a heat and mass balance around both columns, confirmation of vapour composition and pressure levels, supplier budget quotations, subsidy eligibility check and an implementation plan aligned with the next major shutdown.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	Not expected	Medium; confirm methanol inventory, pressure levels and safety distances

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified methanol vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

The information below should be regarded as an initial point of reference. For advice tailored to your project and circumstances, **please consult RVO's subsidy webpages and have your project proposal reviewed by RVO ([project idee toetsen](#))**, which offers the opportunity to:

- Discuss the feasibility of your idea and its likelihood of success
- Present your idea and receive feedback
- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Possible match	Could possibly fall under Energy efficiency (art. 38). Eligibility depends on whether the specific application counts as new for the Netherlands, and whether meaningful risk remains. Whether an equivalent installation already exists in the Netherlands is not established here, but MVR is already widely applied
VEKI	Possible match	Could possibly fall under Energy efficiency (art. 38). It is described as a proven, commercially available technology for evaporation and distillation, supporting the required proven-technology track record, though at least three directly comparable reference projects would need to be confirmed to be eligible for VEKI.
EIA	Highly likely match	Code 270102 [W] "Stoomrecompressie" could fit: a mechanical vapour compressor upgrading vapour to higher temperature and pressure, matching the compression stages used here.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on process-changes and the COP

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Possible	When acceptable for client and technically feasible

This installation is implemented as a process-integrated solution. Financing project costs through an ESCO is feasible only to a limited extent, depending on the project scale, the scope allowed by the client, and/or the level of possible collaboration.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the MVR system is highly integrated with the methanol recovery process, individual components such as the compressors may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to process piping, controls, instrumentation and reboiler connections. Consequently, the solution is unlikely to be suitable for operational lease financing.

FAME Biodiesel

Measure 2: Top vapour recompression with direct bottom injection

Summary

This measure applies top-vapour recompression to the glycerol/methanol distillation column. In the current configuration, methanol-rich vapour from the top of the column is condensed while the bottom section is heated with external steam through the reboiler. By compressing the top vapour to a higher pressure and temperature and injecting it directly into the lower section of the column, part of the reboiler duty can be supplied internally. This reduces external steam demand and improves heat integration in the methanol and glycerol recovery section of the FAME/biodiesel process. Key attention points are compressor selection, column hydraulics, control stability, ATEX requirements, methanol handling, product quality and brownfield integration.



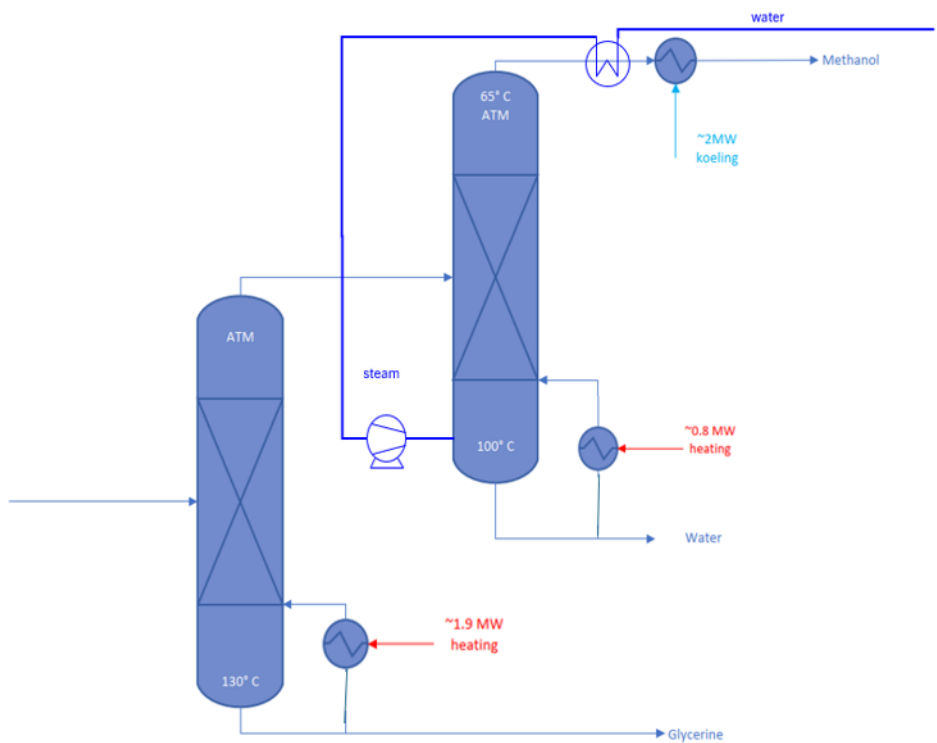
Technical description

Existing process:

In the current distillation configuration, methanol-rich vapour from the top of the column is condensed while the bottom section is heated with external steam through the reboiler. This creates a large simultaneous cooling and heating demand. New process: the overhead vapour is compressed to a higher pressure and temperature and injected directly into the lower section of the column.

New process

Steam is generated in the methanol condenser and is injected into the bottom of the column. This direct vapour recompression concept can significantly reduce external steam demand, with an indicative saving potential of approximately **4,814 MWh/year**, equal to roughly **10%** of the standard FAME/biodiesel factory energy demand. The main technical attention points are compressor selection, column hydraulics, control stability, ATEX classification and brownfield integration.



Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	0.8 MW	13.3%	-6,110 MWh/a
Change in electricity	0.16 MW (COP ~5)		1,296 MWh/a
Total change in energy		10% of the reference plant	4,814 MWh/a
CO ₂ emissions Scope 1			-1,344 ton/a

The change in natural gas is calculated based on the reduction of steam demand with a boiler efficiency of 90%

CAPEX	Indicative	Remark
Main equipment	800 kEUR	Compressors, reboilers, heat exchangers, pumps, controls and/or vendor package
Installation / Lang factor	5	Brownfield factor, ATEX, tie-ins, civil/steel, E&I and downtime
Total CAPEX estimate	4000 kEUR	Indicative screening only

Factors for implementation

Congestion

The measure increases electrical demand by approximately 0.16 MW for the compressor system. Before implementation, the available electrical connection, transformer capacity, MCC capacity and cable routing should be checked. If grid congestion applies, implementation may require load management, phased operation, local generation or reinforcement of the electrical infrastructure.

Retrofitting

Retrofitting is expected to be moderately complex because the MVR system must be integrated directly with two operating distillation columns. Main retrofit items include compressor placement, methanol vapour piping, tie-ins to the existing reboilers, controls, safety instrumentation, ATEX zoning, condensate handling and access for maintenance. Installation should preferably be planned during a scheduled shutdown, with temporary provisions assessed if continuous production must be maintained.

Sustainability and other emissions

Water: no significant direct change is expected compared with the current steam-driven configuration. Indirectly, the lower cooling duty may reduce cooling-water circulation or cooling-tower load, depending on the existing utility configuration. Natural gas: the measure reduces natural gas consumption by approximately 755,400 m³/a, corresponding to a 13.3% reduction compared with the reference plant natural gas consumption. This reduction is achieved by lowering the external steam demand for the glycerol/methanol distillation column through top-vapour recompression and direct bottom injection. NOx: the gas-fired boiler will consume less fuel due to the reduced steam demand. As a result, NOx emissions are expected to decrease. The indicative reduction should be calculated from the actual boiler emission factor and operating profile; a preliminary estimate is approximately 46 kg NOx/year.

Technical maturity

Mechanical vapour recompression is a proven industrial technology for evaporation and distillation applications, including solvent and alcohol recovery. The specific application to methanol-rich vapours in a brownfield FAME/biodiesel plant is technically feasible but requires case-specific engineering. The maturity is therefore assessed as commercially available technology with medium implementation risk, mainly related to compressor selection, process control, ATEX compliance, fouling, turndown behaviour and integration with the existing columns.

Possible suppliers

Potential suppliers and engineering partners include GEA, Sulzer, Alfa Laval, Atlas Copco, Howden/Chart, Piller, Everllence and Busch/Pfeiffer for vacuum-related equipment. Final supplier selection should be based on methanol vapour compatibility, ATEX design, compressor efficiency, temperature lift, turndown range, maintainability and reference cases in solvent recovery or distillation.

Recommendations

Proceed with a site-specific feasibility study focusing on process integration, compressor concept selection, ATEX zoning, electrical capacity, acoustic impact and vendor validation. The next step should include a heat and mass balance around both columns, confirmation of vapour composition and pressure levels, supplier budget quotations, subsidy eligibility check and an implementation plan aligned with the next major shutdown.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	No change	Low to medium; ATEX and HAZOP review required
External safety	Not expected	Medium; confirm methanol inventory, pressure levels and safety distances

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified methanol vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

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Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38). Eligibility depends on whether this specific application counts as new for the Netherlands, and whether meaningful risk remains. Whether an equivalent installation already exists in the Netherlands is not established here, but MVR is already widely applied in several sectors
VEKI	Possible match	Could fall under Energy efficiency (art. 38). It is described as a proven, commercially available technology for evaporation and distillation, supporting the required proven-technology track record, though at least three directly comparable reference projects would need to be confirmed to be eligible for VEKI.
EIA	Highly likely match	Code 270102 [W] "Stoomrecompressie" could fit: a mechanical vapour compressor upgrading vapour to higher temperature and pressure, matching the compression stages used here.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on process-changes and the COP

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Possible	When acceptable for client, technically feasible and of sufficient scale

This installation is implemented as a process-integrated solution. Financing project costs through an ESCO is feasible only to a limited extent, depending on the project scale, the scope allowed by the client, and/or the level of possible collaboration.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the top-vapour recompression system is highly integrated with the methanol and glycerol recovery process and directly connected to the distillation column, individual components such as the compressor, drives and auxiliary equipment may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to the column internals, vapour injection system, process piping, controls, instrumentation and ATEX-related equipment. Consequently, the solution is unlikely to be suitable for operational lease financing.

FAME Biodiesel

Measure 3: One-stage MVR using process vapours to heat the glycerol/methanol distillation reboiler

Summary

This measure applies a one-stage MVR system to the glycerol/methanol distillation section. In the current configuration, methanol-rich process vapour from the top of the column is condensed while the bottom section is heated with external steam through the reboiler. By compressing the process vapour to a higher pressure and temperature and using it indirectly to heat the reboiler, part of the reboiler duty can be supplied internally. This reduces external steam demand and improves heat integration in the methanol and glycerol recovery section of the FAME/biodiesel process. Unlike the direct bottom-injection concept, this measure transfers heat through the reboiler circuit rather than injecting compressed vapour into the lower part of the column. Key attention points are compressor selection, achievable temperature lift, reboiler integration, heat-exchanger design, control stability, ATEX requirements, methanol handling, product quality and brownfield integration.



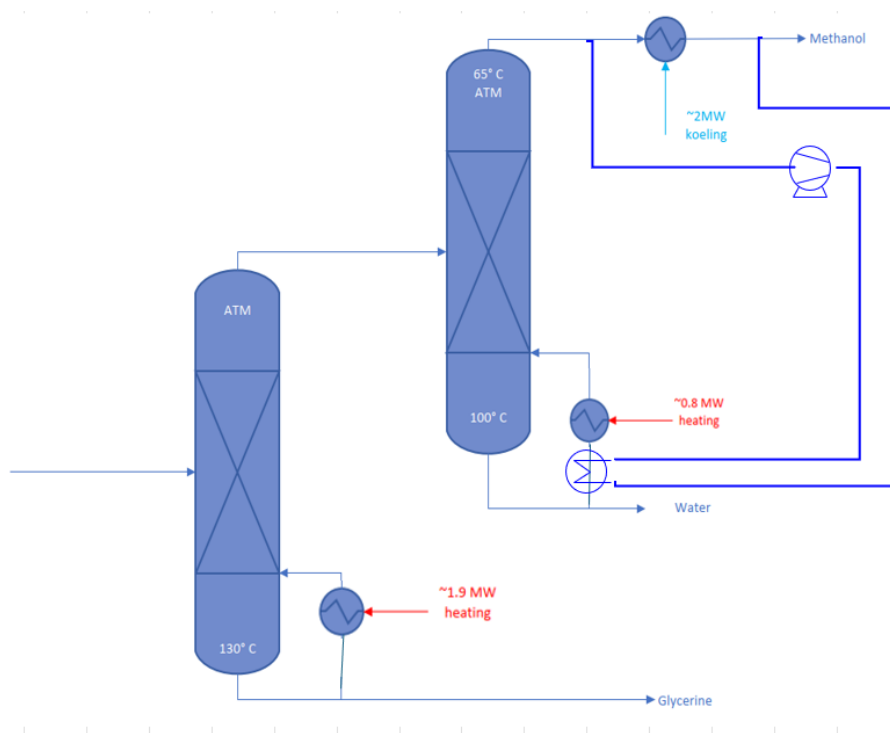
Technical description

Existing process:

In the current distillation configuration, methanol-rich vapour from the top of the column is condensed while the bottom section is heated with external steam through the reboiler. This creates a large simultaneous cooling and heating demand. New process: the overhead vapour is compressed to a higher pressure and temperature and then used indirectly to heat the existing reboiler.

New process

The compressed vapour releases its latent heat through heat exchange in the reboiler circuit and therefore partly replaces conventional reboiler steam, without being injected directly into the lower section of the column. This one-stage MVR concept can significantly reduce external steam demand, with a screening-level saving of approximately **5,600 MWh/a** equal to roughly **10%** of the standard FAME/biodiesel factory energy demand. The main technical attention points are compressor selection, achievable temperature lift, reboiler integration, heat-exchanger design, control stability, ATEX classification, methanol handling, product quality and brownfield integration.



Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	Reduction of reboiler steam, to be developed further per column		
Change in electricity	0.14 MW(COP~6)		
Total change in energy	5,600 MWh/y, approximately.	10% of the reference plant	Screening value or detailed case
CO ₂ emissions Scope 1			-1.344 tons/a

The change in natural gas is calculated based on the reduction of steam demand with a boiler efficiency of 90%

CAPEX	Indicative	Remark
Main equipment	800 kEUR	Compressors, reboilers, heat exchangers, pumps, controls and/or vendor package
Installation / Lang factor	Case-specific	Brownfield factor, ATEX, tie-ins, civil/steel, E&I and downtime
Total CAPEX estimate	4,000 kEUR	Indicative screening only

Factors for implementation

Congestion

The measure increases electrical demand by approximately 0.14 MW for the compressor system. This additional load may be material at sites with limited grid capacity or internal transformer constraints. Before implementation, the available electrical connection, transformer capacity, MCC capacity and cable routing should be checked. If grid congestion applies, implementation may require load management, phased operation, local generation or reinforcement of the electrical infrastructure.

Retrofitting

Retrofitting is expected to be moderately complex because the MVR system must be integrated directly with two operating distillation columns. Main retrofit items include compressor placement, methanol vapour piping, tie-ins to the existing reboilers and condensers, controls, safety instrumentation, ATEX zoning, condensate handling and access for maintenance. Installation should preferably be planned during a scheduled shutdown, with temporary provisions assessed if continuous production must be maintained.

Sustainability and other emissions

Water: no significant direct change is expected compared with the current steam-driven configuration. Indirectly, the lower cooling duty may reduce cooling-water circulation or cooling-tower load, depending on the existing utility configuration. NO_x: the gas-fired boiler will consume less fuel due to the reduced steam demand. As a result, NO_x emissions are expected to decrease. The indicative reduction should be calculated from the actual boiler emission factor and operating profile; a preliminary estimate is approximately 35 kg NO_x/year.

Technical maturity

Mechanical vapour recompression is a proven industrial technology for evaporation and distillation applications, including solvent and alcohol recovery. The specific application to methanol-rich vapours in a brownfield FAME/biodiesel plant is technically feasible but requires case-specific engineering. The maturity is therefore assessed as commercially available technology with medium implementation risk, mainly related to compressor selection, process control, ATEX compliance, fouling, turndown behaviour and integration with the existing columns.

Possible suppliers

Potential suppliers and engineering partners include GEA, Sulzer, Alfa Laval, Atlas Copco, Howden/Chart, Piller, Everllence and Busch/Pfeiffer for vacuum-related equipment. Final supplier selection should be based on methanol vapour compatibility, ATEX design, compressor efficiency, temperature lift, turndown range, maintainability and reference cases in solvent recovery or distillation.

Recommendations

Proceed with a site-specific feasibility study focusing on process integration, compressor concept selection, ATEX zoning, electrical capacity, acoustic impact and vendor validation. The next step should include a heat and mass balance around both columns, confirmation of vapour composition and pressure levels, supplier budget quotations, subsidy eligibility check and an implementation plan aligned with the next major shutdown.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	Not expected	Medium; confirm methanol inventory, pressure levels and safety distances

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified methanol vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

Subsidy screening

The information below should be regarded as an initial point of reference. For advice tailored to your project and circumstances, **please consult RVO's subsidy webpages and have your project proposal reviewed by RVO ([project idee toetsen](#))**, which offers the opportunity to:

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Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38). Eligibility depends on whether this specific application counts as new for the Netherlands, and whether meaningful risk remains. Whether an equivalent installation already exists in the Netherlands is not established here, but MVR is widely applied.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). It is described as a proven, commercially available technology for evaporation and distillation, supporting the required proven-technology track record, though at least three directly comparable reference projects would need to be confirmed to be eligible for VEKI.
EIA	Highly likely match	Code 270102 [W] "Stoomrecompressie" could fit: a mechanical vapour compressor upgrading vapour to higher temperature and pressure, matching the compression step and reboiler heat exchange used here.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on process-changes and the COP

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Possible	When acceptable for client, technically feasible and of sufficient scale

This installation is implemented as a process-integrated solution. Financing project costs through an ESCO is feasible only to a limited extent, depending on the project scale, the scope allowed by the client, and/or the level of possible collaboration.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the one-stage MVR system is highly integrated with the methanol and glycerol recovery process and directly connected to the distillation column, reboiler and condenser system, individual components such as the compressor, heat exchangers, drives and auxiliary equipment may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to process piping, controls, instrumentation, condenser connections and reboiler integration. Consequently, the solution is unlikely to be suitable for operational lease.

FAME Biodiesel

Measure 4: Vacuum steam production from the methanol/glycerol recovery condenser combined with MVR

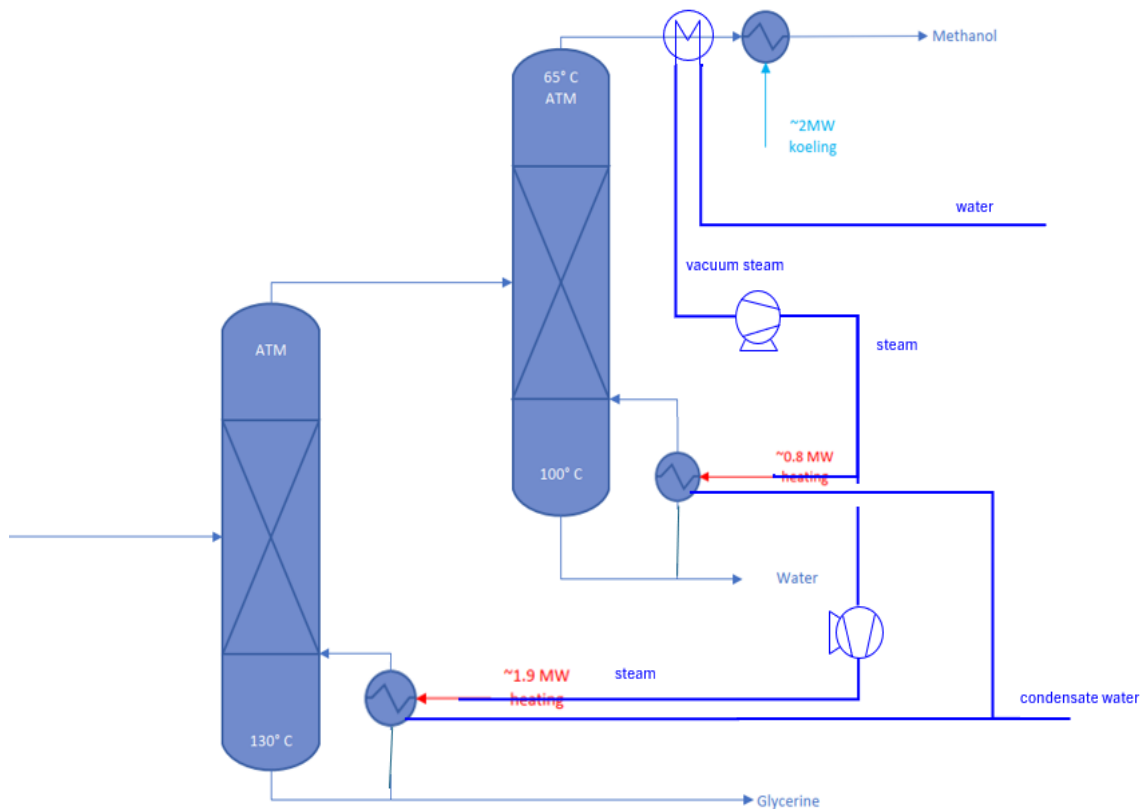
Summary

This measure uses condenser or top-vapour heat from the methanol and glycerol recovery section to produce low-pressure or vacuum steam. By upgrading the recovered heat with MVR, part of the reboiler duty can be supplied internally. This reduces steam demand and improves heat integration in the solvent recovery section of the FAME/biodiesel process. Key attention points are heat-source temperature, vacuum-steam quality, temperature lift, compressor selection, ATEX requirements, electrical capacity and brownfield integration.



Technical description

Existing process: in the current methanol and glycerol recovery configuration, vapours from the top of the columns are condensed while the bottom sections are heated with external steam through the reboilers. This creates a simultaneous cooling and heating demand. New process: the condenser or top-vapour heat is used to generate low-pressure or vacuum steam. This steam is then compressed with a cascade of MVR systems to a higher pressure and temperature, so that it can be reused as a heat source for the reboilers. This concept does not inject compressed process vapour directly into the column; instead, it upgrades recovered condenser heat into useful reboiler heat. The measure can significantly reduce external steam demand, with a screening-level saving of approximately **15,449 MWh/a**, equal to roughly **31%** of the standard FAME/biodiesel factory energy demand. The main technical attention points are heat-source temperature, vacuum-steam generation, compressor selection, temperature lift, condensate quality, process control, ATEX classification, methanol handling and integration with the existing distillation system.



Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-1,9 MW	-46%	-20,949 MWh/a
Change in electricity	0.65 MW (COP ~4)	-	+5,500 MWh/a
Total change in energy	-1,25 MW	31% of the reference plant	15,449 MWh/a
CO ₂ emissions Scope 1			-4,607 ton/a

CAPEX	Indicative	Remark
Main equipment	1,600 kEUR	Vacuum-steam generator, MVR compressor, heat exchangers, reboiler integration, pumps, controls and vendor package
Installation / Lang factor	Case-specific	
Total CAPEX estimate	8,000 kEUR, indicative	Indicative screening only, ATEX could increase CAPEX

The CAPEX estimate is based on the main equipment package required to generate vacuum steam from available condenser or top-vapour heat and upgrade it with MVR. This includes the vacuum-steam generation equipment, compressor package, heat exchangers, reboiler tie-ins, pumps, controls and electrical infrastructure. The estimate is indicative and should be refined with vendor quotations, site layout information, ATEX requirements, tie-in planning and shutdown constraints.

Factors for implementation

Congestion

The measure increases electrical demand because the MVR compressor system requires additional power. The exact power demand depends on the pressure lift, steam flow and temperature level required by the reboilers. Before implementation, the available electrical connection, transformer capacity, MCC capacity and cable routing should be checked. Where grid congestion applies, implementation may require load management, phased operation, local generation or reinforcement of the electrical infrastructure.

Retrofitting

Retrofitting is expected to be moderately complex because the measure must be integrated with the existing condenser and reboiler systems. Main retrofit items include vacuum-steam generation equipment, compressor placement, heat-exchanger integration, piping tie-ins, condensate handling, controls, ATEX zoning and access for maintenance. Installation should preferably be planned during a scheduled shutdown, with detailed attention to process stability during start-up and turndown operation.

Sustainability and other emissions

Water: no significant direct change is expected compared with the current steam-driven configuration. Depending on the condenser and cooling-system configuration, cooling-water demand may decrease because part of the rejected condenser heat is reused. Natural gas: the measure reduces natural gas consumption by approximately 2,590,000 m³/a, corresponding to a 46% reduction compared with the

reference plant natural gas consumption. This reduction is achieved by using condenser or top-vapour heat from the methanol/glycerol recovery section to generate low-pressure or vacuum steam, which is then upgraded with MVR and reused as reboiler heat. NO_x: the gas-fired boiler will consume less fuel due to the reduced steam demand. As a result, NO_x emissions are expected to decrease by approximately 160 kg NO_x/year.

Technical maturity

Vacuum steam production combined with MVR is based on proven principles of heat recovery and mechanical vapour recompression, but the specific integration in a FAME/biodiesel methanol and glycerol recovery section requires case-specific engineering. The maturity is assessed as commercially available technology with medium implementation risk, mainly related to heat-source temperature, vacuum-steam quality, compressor selection, control stability, ATEX compliance and brownfield integration.

Possible suppliers

Potential suppliers and engineering partners include GEA, Sulzer, Alfa Laval, Atlas Copco, Howden/Chart, Piller, Everllence and other suppliers of MVR compressors, heat exchangers and vacuum/steam equipment. Final supplier selection should be based on temperature lift, methanol compatibility, ATEX design, compressor efficiency, maintainability and reference cases in evaporation, solvent recovery or distillation.

Recommendations

Proceed with a site-specific feasibility study focusing on process integration, compressor concept selection, ATEX zoning, electrical capacity, acoustic impact and vendor validation. The next step should include a heat and mass balance around both columns, confirmation of vapour composition and pressure levels, supplier budget quotations, subsidy eligibility check and an implementation plan aligned with the next major shutdown.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	Not expected	Medium; confirm methanol inventory, pressure levels and safety distances

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified methanol vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

The information below should be regarded as an initial point of reference. For advice tailored to your project and circumstances, **please consult RVO's subsidy webpages and have your project proposal reviewed by RVO ([project idee toetsen](#))**, which offers the opportunity to:

- Discuss the feasibility of your idea and its likelihood of success
- Present your idea and receive feedback
- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38). Eligibility depends on whether this specific application counts as new for the Netherlands, and whether meaningful risk remains. Whether an equivalent installation already exists in the Netherlands is not established here, but MVR is widely applied.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). It is described as a proven, commercially available technology for evaporation and distillation, supporting the required proven-technology track record, though at least three directly comparable reference projects would need to be confirmed to be eligible for VEKI.
EIA	Highly likely match	Code 270102 [W] "Stoomrecompressie" could fit: a mechanical vapour compressor upgrading vapour to higher temperature and pressure, matching the compression step and reboiler heat exchange used here.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on process-changes and the COP

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Possible	When acceptable for client and technically feasible

This installation is implemented as a process-integrated solution. Financing of project costs by an ESCO is possible, depending on the scope allowed by the client, and/or the level of possible collaboration.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the vacuum-steam generation and MVR system is highly integrated with the methanol and glycerol recovery process, individual components such as the compressors, vacuum-steam generation equipment, heat exchangers, drives and auxiliary systems may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to condenser systems, reboiler connections, process piping, controls, instrumentation and condensate-handling systems. Consequently, the solution is unlikely to be suitable for operational lease financing.

FAME Biodiesel

Measure 5: High-temperature heat pump or MVR on FAME polishing column

Summary

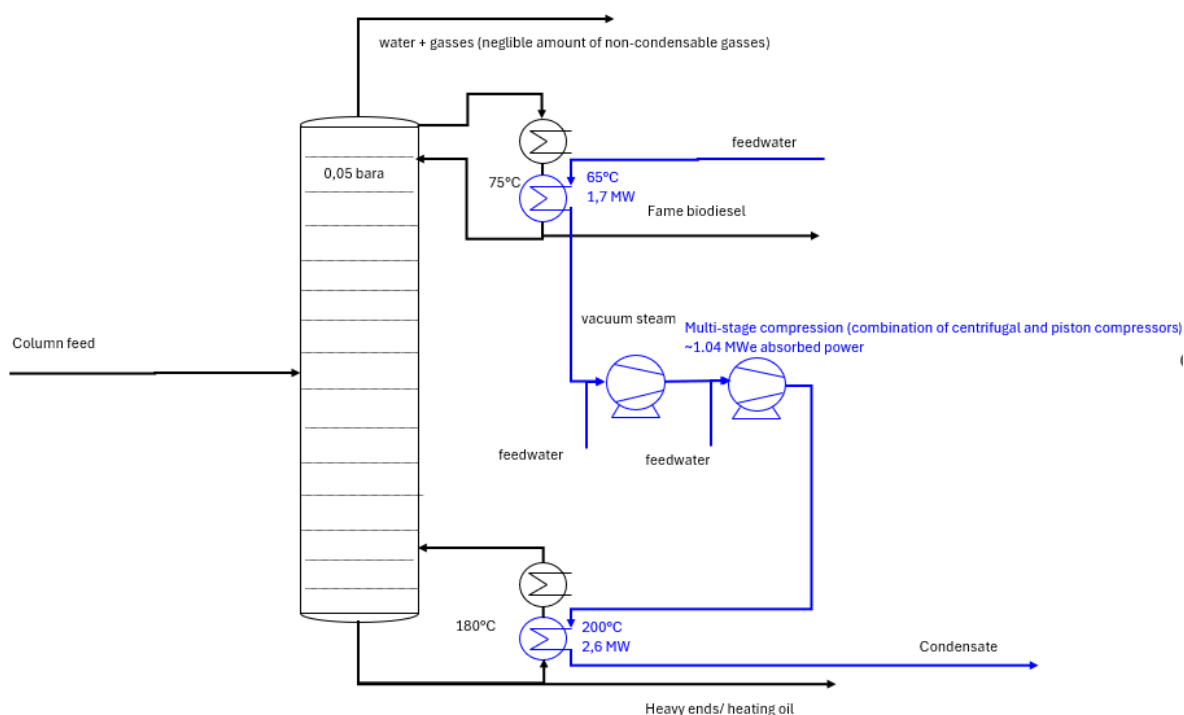
This measure applies a high-temperature heat pump or MVR system to the FAME polishing column. The existing polishing column uses steam for the reboiler while condenser heat is rejected to cooling. By upgrading this available heat to a useful temperature level, part of the reboiler duty can be supplied internally. This reduces steam demand and improves heat integration in one of the main heat-consuming steps of the FAME/biodiesel process. Key attention points are vacuum operation, temperature lift, product quality, fouling, ATEX requirements, electrical capacity and brownfield integration.



Technical description

Existing process:

The FAME polishing column is operated under vacuum to meet final product-quality requirements. The column has an indicative reboiler duty of approximately 2.6 MW, while vapour from the top of the column is condensed and the heat is generally rejected by cooling. This creates a simultaneous heating and cooling demand.



New process:

A high-temperature heat pump or MVR system upgrades the available vapour or condenser heat to a temperature level suitable for reuse in the FAME polishing reboiler. In this way, part of the external steam demand can be replaced by electricity-driven heat upgrading. The longlist screening indicates an energy-saving potential of approximately **14,117 MWh/a**, equal to roughly **28.5%** of the standard FAME/biodiesel factory energy demand. The main technical attention points are the achievable temperature lift, compatibility with vacuum operation, fouling and product quality risks, ATEX classification, compressor or heat-pump selection, control stability and brownfield integration.

Disclaimer

Due to the limited process information made available by the sector, the assessment of MVR integration with the FAME distillation column is based on assumptions regarding stream composition, thermal duties, operating pressures and temperatures. These assumptions were discussed during the workshop with the participating companies.

The assumed conditions may deviate from actual plant operation. Therefore, the proposed configuration, equipment duties, energy savings and economic results should be considered indicative only. The final design may differ and must be validated using site-specific process data and a detailed heat and mass balance.

Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-2.6 MW	42%	22,509 MWh/a
Change in electricity	+0.99 MW (COP ~2.5)		8,332 MWh/a
Total change in energy	14,117 MWh/a	28.5%	
CO ₂ emissions Scope 1			-4,950 ton/a

The change in natural gas is calculated based on the reduction of steam demand with a boiler efficiency of 90%

CAPEX	Indicative	Remark
Main equipment	2,400 kEUR	5 stages to 3 bar (~1000 kEUR, compression to final pressure ~1000 kEUR) + two reboilers (400 kEUR)
Installation / Lang factor	~5	
Total CAPEX estimate	12,000 kEUR	

Factors for implementation

Congestion

The measure increases electrical demand by approximately 0.99 MW for the compressor system. This additional load may be material at sites with limited grid capacity or internal transformer constraints. Before implementation, the available electrical connection, transformer capacity, MCC capacity and cable routing should be checked. If grid congestion applies, implementation may require load management, phased operation, local generation or reinforcement of the electrical infrastructure.

Retrofitting

Retrofitting is expected to be moderately complex because the MVR system must be integrated directly with two operating distillation columns. Main retrofit items include compressor placement, methanol vapour piping, tie-ins to the existing reboilers, controls, safety instrumentation, ATEX zoning, condensate handling and access for maintenance. Installation should preferably be planned during a scheduled shutdown, with temporary provisions assessed if continuous production must be maintained.

Sustainability and other emissions

Water: no significant direct change is expected compared with the current steam-driven configuration. Indirectly, the lower cooling duty may reduce cooling-water circulation or cooling-tower load, depending on the existing utility configuration. Natural gas: the measure reduces natural gas consumption by approximately 2,783,000 m³/a, corresponding to a 42.5% reduction compared with the reference plant natural gas consumption. This reduction is achieved by lowering the external steam demand for the FAME polishing column by upgrading available vapour or condenser heat with a high-temperature heat pump or MVR system and reusing it as reboiler heat. NO_x: the gas-fired boiler will consume less fuel due to the reduced steam demand. As a result, NO_x emissions are expected to decrease. The indicative reduction should be calculated from the actual boiler emission factor and operating profile; a preliminary estimate is approximately 145 kg NO_x/year.

Technical maturity

Mechanical vapour recompression is a proven industrial technology for evaporation and distillation applications, including solvent and alcohol recovery. The specific application to methanol-rich vapours in a brownfield FAME/biodiesel plant is technically feasible but requires case-specific engineering. The maturity is therefore assessed as commercially available technology with medium implementation risk, mainly related to compressor selection, process control, ATEX compliance, fouling, turndown behaviour and integration with the existing columns.

Possible suppliers

Potential suppliers and engineering partners include GEA, Sulzer, Alfa Laval, Atlas Copco, Howden/Chart, Piller, Everllence and Busch/Pfeiffer for vacuum-related equipment. Final supplier selection should be based on methanol vapour compatibility, ATEX design, compressor efficiency, temperature lift, turndown range, maintainability and reference cases in solvent recovery or distillation.

Recommendations

Proceed with a site-specific feasibility study focusing on process integration, compressor concept selection, ATEX zoning, electrical capacity, acoustic impact and vendor validation. The next step should include a heat and mass balance around both columns, confirmation of vapour composition and pressure levels, supplier budget quotations, subsidy eligibility check and an implementation plan aligned with the next major shutdown.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Working medium in heat pump. ATEX and HAZOP review required.
External safety	Not expected	Medium; confirm methanol inventory, pressure levels and safety distances

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified methanol vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

Based on the indicative figures presented above for the reference plant, a concise assessment of the subsidies that may potentially be applicable is provided below.

The information below should be regarded as an initial point of reference. For advice tailored to your project and circumstances, **please consult RVO's subsidy webpages and have your project proposal reviewed by RVO ([project idee toetsen](#))**, which offers the opportunity to:

- Discuss the feasibility of your idea and its likelihood of success
- Present your idea and receive feedback
- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38). Eligibility depends on whether the specific technology and application chosen (heat pump or MVR) counts as new for the Netherlands, and whether meaningful risk remains. The maturity evidence given addresses mechanical vapour recompression specifically; it does not establish this for the heat-pump alternative named in this measure.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). The proven, commercially available characterization given here applies specifically to mechanical vapour recompression; it does not cover the heat-pump alternative named in this measure, whose own track record would need to be established separately if that route is chosen instead.
EIA	Possible match	This measure names two possible technologies, and they point to different codes. If MVR is used, code 270102 [W] "Stoomrecompressie" could possibly apply. If a heat pump is used instead, code 221103 [W] "Warmtepomp" could possibly apply, which requires a halogen-free refrigerant and a minimum COP that depends on the temperature lift between heat source and delivery, neither of which is specified here.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on process-changes and the COP

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Possible	When acceptable for client and technically feasible

This installation is implemented as a process-integrated solution. Financing of project costs by an ESCO is possible, the scope allowed by the client, and/or the level of possible collaboration.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the high-temperature heat pump or MVR system is highly integrated with the FAME polishing process and directly connected to the polishing column, condenser and reboiler system, individual components such as the compressor or heat-pump package, heat exchangers, drives and auxiliary equipment may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to process piping, controls, instrumentation, condenser connections, reboiler integration and vacuum-system interfaces. Consequently, the solution is unlikely to be suitable for operational lease financing.

FAME Biodiesel

Watch List

Summary

The FAME/biodiesel watchlist includes measures that were identified as technically relevant but were not selected for detailed Top 5 elaboration. These options mainly address cooling optimisation, alternative phase separation, membrane pre-separation and vacuum-system improvement. Compared with the selected priority measures, their generic energy-saving impact is smaller, their applicability is more site-specific, or their technical uncertainty is higher. They should therefore be revisited during site-specific feasibility studies, especially where local utility systems, equipment configuration, product-quality requirements or existing vacuum and separation systems create a stronger business case.



M1 – Ice chilling for the FAME polishing vacuum system instead of chilled water

This measure considers ice chilling in the FAME polishing vacuum system as an alternative utility concept around the condenser and vacuum system. The main energy benefit is expected to come from reducing steam consumption for the steam ejector by improving condensation and lowering the vapour load handled by the ejector system. Any change in chilled-water or cooling-electricity demand is secondary and should be assessed site-specifically. The measure may be relevant for sites with existing steam ejectors, high vacuum-system steam use, constrained chilled-water systems or opportunities to operate ice chilling during off-peak electricity periods.

M2 – Membrane phase separation instead of centrifugal separation in the FAME/glycerol separation step

This measure replaces centrifugal phase separation with membrane-based separation. The energy benefit comes mainly from avoiding centrifuge electricity consumption. In the reference plant this electricity demand is relatively small, which results in a limited overall energy impact. The measure may still be relevant where membranes improve separation quality, reduce downstream losses or simplify operation, but applicability depends strongly on fouling behaviour, membrane lifetime and product-quality requirements.

M3 – Gravity phase separation instead of centrifugal separation in the FAME/glycerol separation step

This measure replaces centrifugal phase separation with gravity-based separation. Like membrane-based separation, the direct energy benefit mainly comes from avoiding centrifuge electricity consumption. Applicability depends on residence time, density difference between phases, footprint, product quality, separation efficiency and operational stability.

M9 – Membrane pre-separation upstream of the methanol/glycerol recovery columns to reduce distillation load

This measure uses membrane pre-separation upstream of distillation to reduce the load on methanol or glycerol recovery columns. It has a potentially higher energy impact than the separation measures because it can reduce reboiler duty. However, the technology risk is also higher. Feasibility depends on membrane selectivity, fouling sensitivity, methanol and glycerol recovery performance, product quality and integration with the existing distillation system.

M10 – Dry vacuum pump instead of steam ejector in the FAME polishing vacuum system

This measure replaces steam ejectors with dry vacuum pumps in the FAME polishing section. It reduces steam consumption for vacuum generation but introduces additional electricity demand. The measure is relatively practical for sites with existing steam ejectors, although the total saving is smaller than the main MVR and heat-pump concepts. Key attention points are vacuum level, condensable vapours, ATEX requirements, maintenance, noise and integration with the existing polishing column.

FAME Biodiesel

Longlist

Summary

The FAME/biodiesel longlist provides an overview of potential energy-saving measures for the standard FAME/biodiesel factory. The measures mainly focus on reducing steam demand in methanol recovery, glycerol/methanol separation and FAME polishing, as these thermal separation steps dominate the energy balance. Additional options include improvements to phase separation, vacuum generation and alternative recovery concepts. The longlist is intended as a screening tool to compare measures on indicative energy-saving potential, expected payback and technical applicability before selecting the most promising options for further elaboration.

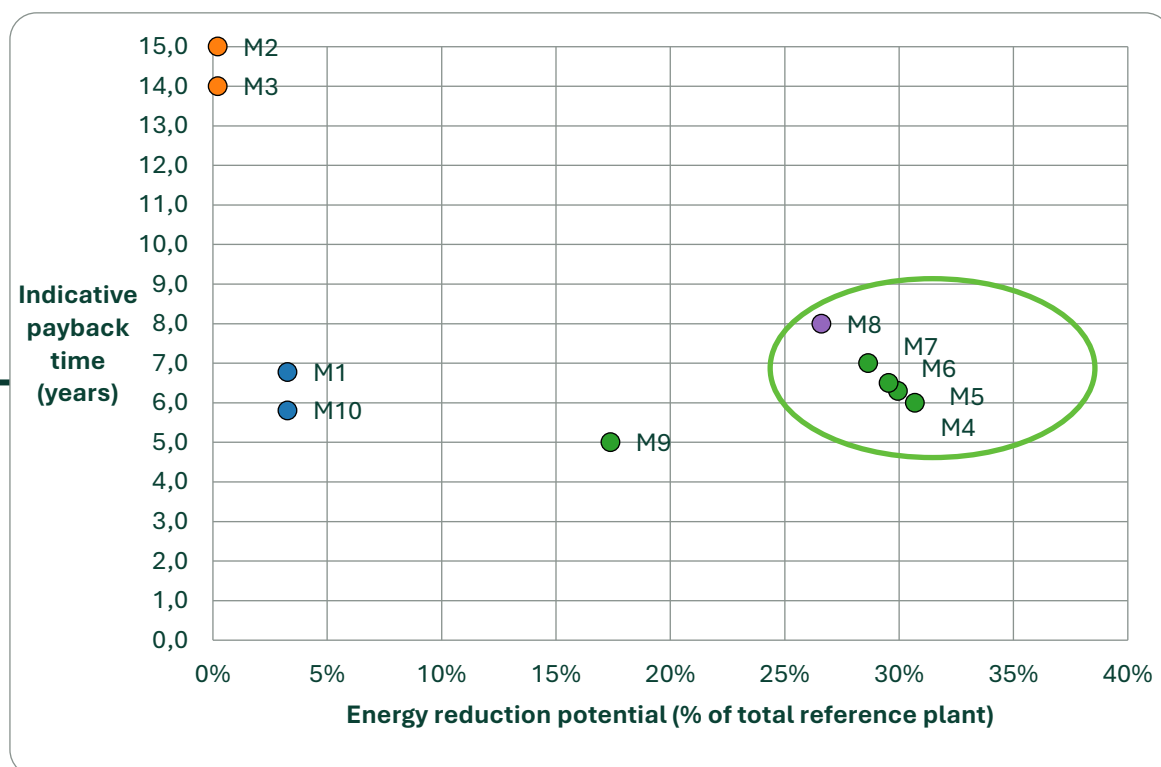


#	M	Measure	Process step	Indicative Energy Savings	Description
1		Ice chilling for the FAME polishing vacuum system instead of chilled water	Polishing	5,904 GJ/y	Steam ejector steam reduction; budget CAPEX EUR 0.4m
2		Membrane phase separation instead of centrifugal separation in the FAME/glycerol separation step	Separation	382 GJ/y	Avoided centrifuge electricity; budget CAPEX EUR 0.5m
3		Gravity phase separation instead of centrifugal separation in the FAME/glycerol separation step	Separation	382 GJ/y	Avoided centrifuge electricity; budget CAPEX EUR 0.25m
4	M1	Two-stage MVR on the methanol rectification and glycerol/methanol distillation columns	Solvent recovery	55.543 GJ/y	Longlist energy score 4 midpoint; user benchmark payback 6.3 y
5	M2	Top-vapour recompression with direct bottom injection in the glycerol/methanol distillation column	Solvent recovery	54.196 GJ/y	Longlist energy score 4 midpoint; user benchmark payback 6.3 y
6	M3	One-stage MVR using process vapours to heat the glycerol/methanol distillation reboiler	Solvent recovery	53.460 GJ/y	Longlist energy score 4 midpoint; user benchmark payback 6.3 y
7	M4	Vacuum steam production from the methanol/glycerol recovery condenser combined with MVR	Solvent recovery	51,840 GJ/y	Longlist energy score 4 midpoint; user benchmark payback 6.3 y
8	M5	High-temperature heat pump or MVR on FAME polishing column	Solvent recovery / Polishing	48.137 GJ/y	Longlist energy score 4 midpoint; user benchmark payback 6.3 y
9		Membrane pre-separation upstream of the methanol/glycerol recovery columns to reduce distillation load	Solvent recovery	31.451 GJ/y	Longlist energy score 3 midpoint; CAPEX proxy equal to MVR benchmark
10		Dry vacuum pump instead of steam ejector in the FAME polishing vacuum system	Polishing	5.904 GJ/y	Steam ejector replacement; EUR 0.25m CAPEX; estimated 20 kW power penalty

Fame Biodiesel top 5 selection

The figure shows why the selected FAME/biodiesel measures focus mainly on the thermal separation steps of the reference plant. The largest energy users are linked to methanol recovery, glycerol/methanol separation and FAME polishing, where high reboiler duties occur together with significant condenser heat rejection. This creates strong potential for heat integration, vapour recompression and electrified heat upgrading.

The selected measures therefore target the dominant heat users shown in the figure. M4, M5, M6 and M7 focus on the methanol and glycerol recovery columns, where MVR concepts can reuse vapour heat that would otherwise be rejected. M8 focuses on the FAME polishing column, which is also one of the main heat-consuming steps and offers potential for high-temperature heat-pump or MVR integration. Measures outside this selection generally have a smaller contribution to the total energy balance or are more site-specific, such as centrifuge electricity reduction, chilled-water optimisation, membrane separation or steam-ejector replacement.



Selection note

M4, M5, M6 and M7 are the most relevant FAME/biodiesel measures from an energy perspective because they directly target the methanol and glycerol recovery section, where simultaneous reboiler and condenser duties create a strong opportunity for vapour recompression and heat integration. M8 is also retained in the top five because the FAME polishing reboiler is one of the largest individual heat users in the reference plant and offers significant potential for high-temperature heat-pump or MVR integration. M10 is a practical and relatively focused measure for plants that still use steam ejectors for vacuum generation, but its total energy-saving potential is smaller than the main MVR and heat-pump measures. M1, M2 and M3 have limited impact on the total energy balance because they mainly affect cooling or centrifuge electricity, which are small compared with the overall thermal demand. M9 may be promising where membrane pre-separation can demonstrably reduce distillation load, but it remains more uncertain and should be treated as a watchlist or site-specific option.



Reference Plant #2

Crushing

Summary

The reference plant for crushing in the oils and fats sector covers grinding through oil extraction with hexane. Energy use is highest in the DTDC unit, where hexane is recovered from ground beans; bean conditioning and the hexane evaporator are also major heat consumers.

Most crushing plants already have significant heat integration. The main proposed measures are the combination of an MVR for the hexane evaporator combined with a heat pump using residual heat from the DT section and a measure to reuse the heat of the vapour from the DC section. The combination of an MVR with a DT-section heat pump saves about 25% energy.

The measures require significant installation changes that can be delivered by industry technology providers. Subsidy potential is good and permits are not expected to be a major barrier. As all measures are process-integrated, they are generally less suitable for standard Esco or operational lease financing.

Description reference plant

Production process

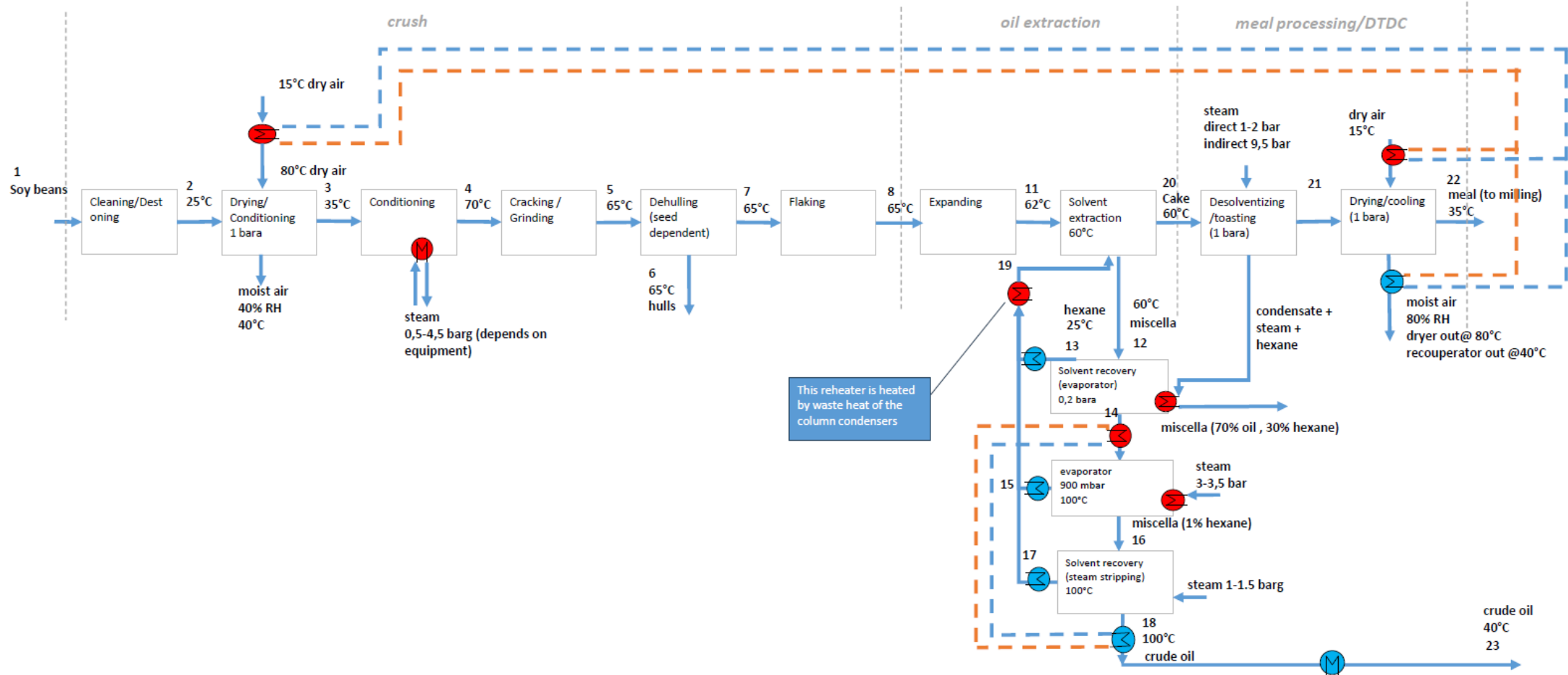
The Crushing reference plant represents a simplified reference case for soybean crushing in the MVO sector. It describes how a typical plant converts soybeans into crude oil, meal and hulls, and provides the common basis for comparing energy-saving measures. The detailed process configuration, main unit operations and energy users are explained in the following sections.

Capacity reference plant

Parameter	Value	Unit / remark
Soybean feedstock capacity	912,500	tonnes/year, based on 2,500 tonnes/day and 8,000 h/year
Operating hours	8,000	hours/year
Soybean oil mass fraction	21%	workshop input
Moisture fraction in feed	12%	workshop input
Hull fraction	6%	input used in the reference plant
Hull production	54,750	tonnes/year
Crude oil production	174,070	tonnes/year
Meal production	644,062	tonnes/year
Water output	39,619	tonnes/year, including condensate and moisture in drying air
Hexane in/out balance	0	tonnes/year net, assuming 100% hexane recovery for simplification

Process description

In the standard Crushing factory, soybeans are mechanically and thermally prepared before oil extraction. The process starts with cleaning, drying and conditioning of the beans, followed by dehulling, cracking or grinding, flaking and solvent extraction. Hexane is used as extraction solvent and is recovered downstream through evaporation, condensation and steam stripping. The remaining meal is treated in a DTDC system, where desolventising, toasting, drying and cooling take place. The factory is strongly heat-driven. The main energy users are the drying and conditioning section, the DTDC system and the solvent recovery system. The DTDC and solvent recovery sections are especially important because they involve steam use, hexane evaporation and opportunities for internal heat recovery, MVR and heat pump integration.



Unit operations

Unit operation	Function	Importance for energy analysis
Cleaning / destoning	Removal of foreign material before processing	Limited direct energy relevance, but important for reliable downstream operation.
Drying and conditioning	Moisture reduction and heating of soybeans	4.56 MW
Dehulling	Separation of hulls from beans	Produces approximately 54,750 tonnes/year hulls. Potential relevance for hot-air reuse, but savings are expected to be limited.
Cracking / grinding / flaking	Mechanical preparation for extraction	Mainly electrical energy. Enlarging units can reduce electricity and auxiliary air use, but savings are considered limited and case specific.
Solvent extraction	Oil extraction using hexane	Determines hexane circulation and downstream evaporation load.
Solvent recovery evaporators	Recovery of hexane from miscella	The first evaporator duty is approximately 6.37 MW, while the second evaporator steam duty is approximately 0.81 MW. This is one of the key areas for the potential application of an MVR.
Solvent steam stripper	Final hexane removal from crude oil	Heat duty is relatively small in the reference plant balance, because the calculation assumes only heating of soy oil and simplified hexane evaporation.
DTDC	Desolventizing, toasting, drying and cooling of meal	Major heat consumer, with direct steam around 5.92 MW and indirect steam around 2.15 MW, total approximately 8.08 MW.
Utilities	Boiler, steam distribution and losses	Utility losses are estimated at approximately 2.10 MW in the reference plant balance, making optimization of utilities a logical step.

Process variation

Existing soybean crushing plants can differ significantly in feedstock type, moisture content, dehulling configuration, hexane/feed ratio, extractor design, DTDC age and configuration, heat recovery already present, solvent recovery design, vacuum systems and the degree of internal heat integration. These differences strongly influence whether measures such as MVR on evaporators, VRS (Vapour Recovery System) on DTDC, heat pumps on DT waste heat, seed preheating or Quickdrip are technically and economically attractive.

Workshops with the sector indicated that some technologies are already commercially available, such as VRS technology for reusing energy from DC to DT, while other measures, such as membranes for hexane extraction or alternative solvents, are not considered realistic energy-saving measures before 2030 in the standard case.

Mass and energy balance

Energy / utility	Value	Unit	Remark
Conditioning duty	2.97	MW	Cooling from approximately 75°C to 35 °C.
2nd hexane evaporator steam duty	0.81	MW	3 to 3.5 bar(g) steam. Hexane evaporation on 25°C duty
Steam stripper duty	0.012	MW	Simplified duty, only heating of soy oil included in the calculation.
DT direct steam	5.92	MW	Direct steam to DTDC.
DT indirect steam	2.15	MW	Indirect steam to DTDC.
Total DT heat demand	8.08	MW	Direct + indirect steam.
Utility losses	2.10	MW	Estimated boiler and distribution losses.
Total with energy reuse (total natural gas consumption)	14	MW	

Waste heat			
<i>Drying section duty (covered with hot water network)</i>	<i>4.56</i>	<i>MW</i>	<i>Estimated from dryer enthalpy balance with 80°C inlet air and 40% RH outlet air.</i>
<i>DC ((covered with hot water network)</i>	<i>4.75</i>	<i>MW</i>	
<i>1st hexane evaporator duty (heated with DT vapours)</i>	<i>6.37</i>	<i>MW</i>	<i>Heat duty of first evaporator, linked to waste steam or recovered heat in the reference plant.</i>
Total Heat users (including waste heat)	29.66	MW	

The reference plant has an external heat demand of approximately 14 MW, equal to around 400,000 GJ/year. This value reflects the net external heat demand after internal recovery, while the gross thermal balance is higher. This distinction is important because many measures overlap with existing heat recovery and are therefore not additive.

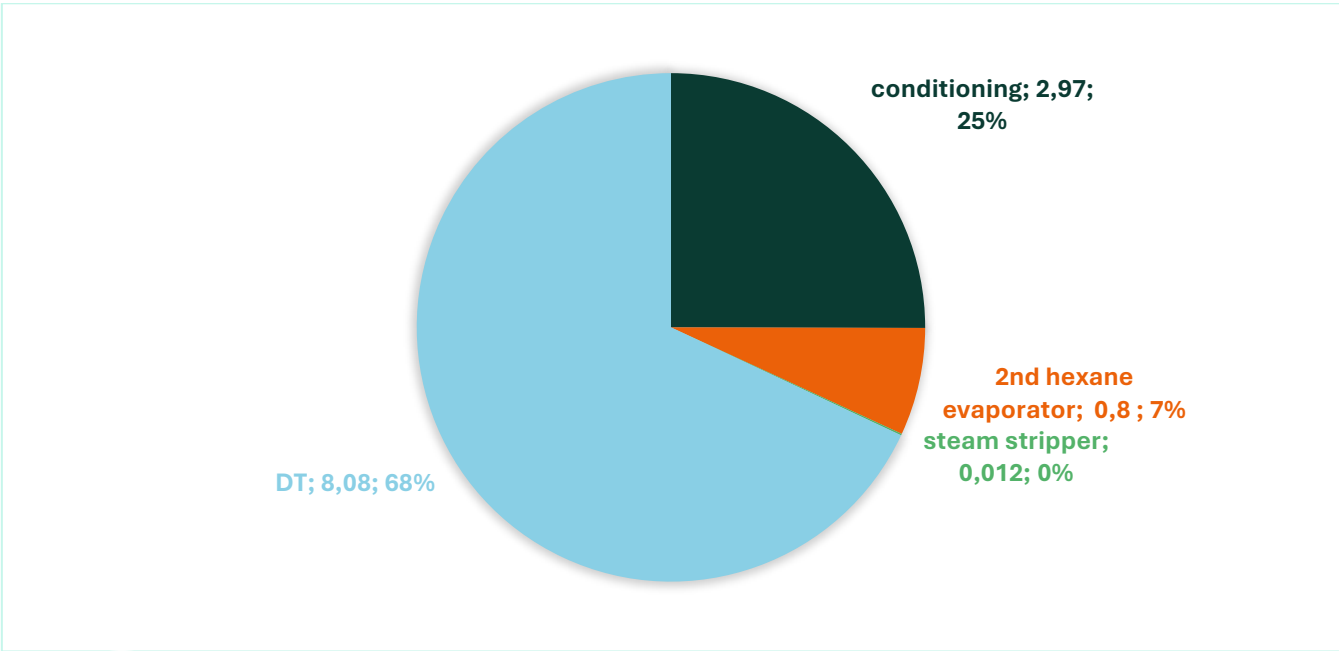
Energy analysis

The energy analysis indicates that the Crushing reference plant is primarily driven by thermal energy demand in the DTDC, solvent recovery, and drying and conditioning sections. The reference energy basis consists of natural gas use for steam generation and an assumed electrical energy use for the Crushing plant. The electrical energy use is estimated as 10% of the total energy use of the plant and is therefore not included in the figure below.

The figure below shows the steam usage of the main thermal energy users in the reference plant. This steam is assumed to be generated by a natural gas-fired boiler. As a result, the steam balance gives a good insight into the natural gas consumption of the plant and into the way thermal energy is used across the main process sections.

The DTDC remains the largest individual heat consumer, while the solvent recovery evaporators represent a significant heat-integration opportunity, particularly for the application of mechanical vapour recompression. The analysis also identifies a substantial amount of recoverable waste heat, although part of this heat is already reused internally within the process. This is an important boundary condition when assessing energy-saving measures, because the implementation of one measure can reduce the available heat source or heat sink for another.

As a result, the identified savings should not be considered fully additive without further process integration assessment. The most relevant energy-saving themes for the Crushing reference plant are the recovery and upgrading of DTDC waste heat, mechanical vapour recompression in solvent recovery, improved hexane management upstream of the DTDC, seed preheating using residual heat, and optimisation of the utility system. Measures such as alternative solvents and membrane-based hexane extraction are considered less suitable for short-term implementation, mainly due to technology maturity, retrofit complexity, safety considerations, or limited direct energy benefit in the reference plant context.



Top 4 measures

The top four were selected by assessing the longlist (Longlist) against the Crushing reference plant and by considering both energy relevance and practical applicability. Due to the existing heat integration and the applied methodology and selection criteria for identifying measures, only a limited number of measures were identified for the crushing plant. The selection was not based on indicative energy saving alone.

Measures were prioritised where they address a clearly present energy user in the reference plant, have a realistic route to implementation before 2030, can be applied in existing brownfield crushing plants, and provide a sufficiently concrete basis for further technical and business-case development. Special attention was given to the interaction between measures, because several options use the same waste heat sources or reduce the same steam demand. For this reason, calculated savings should not be considered additive without a site-specific heat integration assessment.

#	Measure	Indicative saving	Relative to reference plant	Pay back time	Selection rationale
1A	M10 - MVR on hexane evaporator / reboilers	0 MWh/a	0%, waste heat cannot be used	NA	Largest practical saving in solvent recovery and directly targets a main heat consumer.
1B	M8 - Heat pump / indirect MVR on DT waste heat	-3,346 MWh/a	~2.7%	NA	High potential for upgrading DT waste heat but requires careful integration with existing heat reuse.
2: 1A + 1B (combined)	Combine measure 1 and 2 into one measure	-32,081 MWh/a	26%	5-10 years	Combine measure 1A and 1B into a measure that saves a lot of natural gas
3	M7 - VRS: reuse energy from DC to DT	-3,529 MWh/a	3%	5-10 years	Commercially available technology with brownfield potential, depending on DTDC configuration.

Crushing

Measure 1A: MVR on hexane evaporator / reboilers

Summary

Mechanical vapour recompression can be applied to the hexane evaporator or reboiler system to reduce the need for external steam in solvent recovery. In the existing process, hexane vapours are condensed while fresh steam is used to provide the required evaporation duty. With MVR, these vapours are compressed to a higher temperature level and reused as a heat source for the evaporator or reboiler. This improves internal heat recovery and reduces the reliance on steam generation, while keeping the main solvent recovery process route unchanged. The measure is technically mature, but practical feasibility depends on the existing evaporator configuration, ATEX requirements, available space, electrical capacity and integration with the broader solvent recovery system.



Technical description

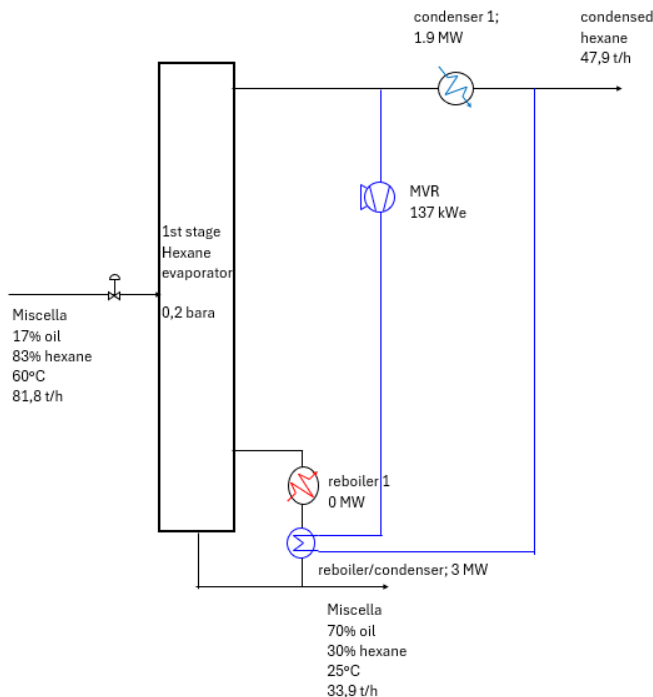
Existing process

Hexane is recovered in a multistage evaporator. The hexane is evaporated in a reboiler and condensed using cooling water. Most of the hexane is evaporated in the first stage evaporator (~80-90%), therefore the first stage evaporator is the most energy-intensive evaporator. The first stage evaporator operates at 0.2 bara with a hexane condensation temperature of 25°C. The reboiler is operated at around 30-35°C and 0.2 bara. This process is very well suited for the application of an MVR.

Process with MVR

An MVR compresses the evaporator vapours from 0.2 to 0.37 bara using one or two compression stages. A new condenser/reboiler condenses the hexane while supplying heat to the evaporator. This can fully replace the evaporator heat duty of 3.2 MW. The compressor(s) consume 217 kWe, resulting in an expected COP of approximately 15.

In the reference plant this option does not reduce overall energy consumption as a standalone measure, because the MVR replaces already recovered waste heat and therefore does not lower natural gas demand. It should therefore be combined with Measure 1B, with this combined configuration forming Measure 1A+1B.



Key numbers

Energy consumption	Indicative	Relative	Annual
Change in natural gas	-3.2 MW of heat saved	NA	Waste heat cannot be used.
Change in electricity	+0.217 MW	-	+1736 MWh/a
Total change in energy		-	0
CO₂ emissions Scope 1		n/a	0 ton/a

The change in natural gas is calculated based on the reduction of steam demand.

CAPEX	Indicative	Remark
Main equipment	~350 kEUR	
Installation / Lang factor	~5	
Total CAPEX estimate	1,750 kEUR	Indicative screening, ATEX requirements can impact this price.

Factors for implementation

Congestion

The MVR system increases the electrical load of the site because the compressor, auxiliaries and control equipment require additional power. In the screening case, the additional electrical demand is limited compared with the avoided steam demand, but it may still be relevant for sites with limited grid capacity, transformer spare capacity or medium-voltage infrastructure. Because of the small electrical load of 0.22 MW hybrid operation is not relevant.

Retrofitting

Retrofitting MVR on the hexane evaporator or reboiler system requires close integration with the existing solvent recovery section. The main retrofit scope typically includes the compressor package, condenser/reboiler modifications, heat exchangers, vapour and condensate piping, controls, instrumentation, safety systems and electrical infrastructure. Brownfield implementation must take account of available space, tie-in locations, downtime windows, ATEX zoning and the need to maintain stable solvent recovery and product quality during operation. Supplier input and a detailed site survey are required to confirm the final integration concept.

Sustainability and other emissions

This standalone measure does not reduce natural gas use and therefore does not reduce CO₂ emissions.

Technical maturity

Mechanical vapour recompression is a proven technology in evaporation and industrial heat recovery applications.

Possible suppliers

Relevant suppliers for MVR on hexane evaporators or reboilers are mainly found among large international technology providers that design and deliver turnkey oilseed extraction, solvent recovery and miscella-distillation systems. In the vegetable oil industry, this application is often described as vapour recompression, mechanical vapour recompression or MVR-driven miscella distillation. The concept focuses on reusing the latent heat of hexane vapours from the miscella evaporators by compressing these vapours to a higher pressure and temperature level, so they can be reused as a heating medium for the evaporator or reboiler instead of being fully condensed against cooling water. Typical supplier categories include oilseed-crushing technology providers such as Desmet, Myande and Anderson International, MVR and distillation specialists such as GEA and Sulzer, compressor suppliers such as Howden/Chart, Piller, Atlas Copco and Everllence, heat-exchanger suppliers such as Alfa Laval and Kelvion, and specialised ATEX/EPC integration partners. Final supplier selection should focus on proven experience with solvent-containing process environments, hexane safety, ATEX compliance, achievable temperature lift, compressor efficiency, integration with existing miscella evaporators and the ability to deliver a complete system.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Depends on use of waste heat.	Low impact
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	Change of hexane volume expected.	Medium; Management of change and ATEX review required

Overall expected permit impact: medium. In combination with measure 1B this measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

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- Discuss the feasibility of your idea and its likelihood of success
- Present your idea and receive feedback
- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Highly likely no match	No AGVV article applies: this measure's own figures show 0 ton/a CO ₂ reduction standalone, so there's no environmental or CO ₂ benefit for DEI+ to support at this scope.
VEKI	Highly likely no match	Same basis: with zero CO ₂ reduction and only added electricity use standalone, there's no CO ₂ -saving benefit here for VEKI to subsidize, so no article classification applies either.
EIA	Highly likely match	Code 270102 [W] "Stoomrecompressie" doesn't require any net energy saving, only that the equipment matches its description (a vapour compressor upgrading vapour to higher pressure and temperature)
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on process-changes and the COP

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	Possibly financial lease
External ownership & operation (ESCO)	Unlikely	Insufficient scale

This installation is implemented as a process-integrated solution. Financing of project costs by an ESCO is unlikely because of insufficient scale.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the MVR system is highly integrated with the hexane recovery process and directly connected to the evaporator, condenser and solvent recovery system, individual components such as the compressor package, heat exchangers, drives and auxiliary equipment may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to the evaporator system, condenser/reboiler configuration, vapour and condensate piping, controls, instrumentation and ATEX-related equipment. Consequently, the solution is unlikely to be suitable for operational lease financing.

Crushing

Measure 1B:

Heat pump indirect MVR on DT waste heat

Summary

A heat pump or indirect MVR system can be applied to upgrade waste heat from the DTDC into useful process heat. In the existing process, the DTDC releases heat through vapour, off-gas and drying or cooling streams, while other parts of the plant still require steam or hot utility heat. This measure upgrades the available DT waste heat to a higher temperature level so it can be reused within the DTDC system or in another suitable heat demand. By converting residual heat into useful process heat, the measure reduces the need for external steam generation while keeping the main production route unchanged. Practical feasibility depends on the availability of a continuous waste heat source, a suitable heat sink, existing heat recovery, ATEX requirements, electrical capacity and the integration possibilities within the current DTDC configuration.



Technical description

PROCESS DESCRIPTION

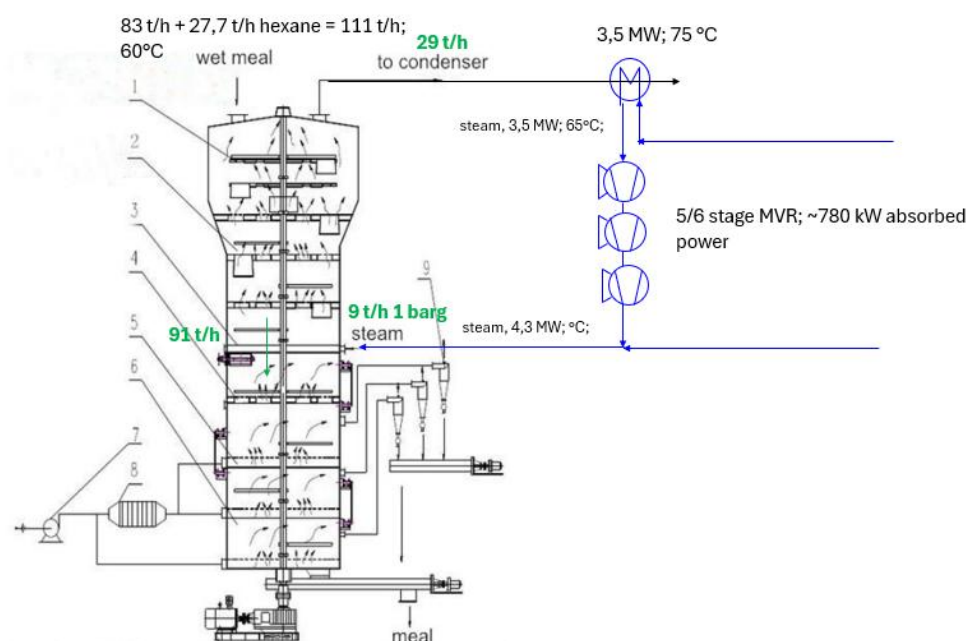
Existing process

The upper section of the DTDC column, known as the Desolventizer-Toaster (DT) section, is heated with 2.1 MW of 9.5 bar(g) steam and approximately 9 t/h (~6 MW) of direct steam injection at 1 bar(g). The direct steam strips hexane from the product. The resulting off-gas, consisting of hexane and steam, is normally condensed in the hexane evaporator condenser/reboiler, where the heat is recovered.

New process

The DT vapours are condensed in a condenser/evaporator that generates water vapour at 65°C and 0.25 bara. This vapour is compressed to 2 bara and reused as direct steam injection in the DT section. The compressor consumes approximately 820 kWe and achieves an expected COP of around 8. The MVR system replaces approximately 6.6 t/h of steam.

This measure offers limited natural gas savings in the reference plant setting, as the off-gas heat is currently recovered and reused in the hexane rectification process. Diverting this heat to the MVR system will increase the steam demand of the hexane rectification section, thereby reducing the net energy savings of the measure.



Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-1.24 MW		-11,047 MWh/a
Change in electricity	+0.82 MW		+6,548 MWh/a
Total change in energy	-0.42 MW	-2.7%	-4,526 MWh/a
CO2 emissions Scope 1			-2,435 ton/a

The change in natural gas is calculated based on the reduction of steam demand with a boiler efficiency of 90%

CAPEX	Indicative	Remark
Main equipment	~1,700 kEUR for main equipment	Compressors, reboilers, heat exchangers, pumps, controls and/or vendor package
Installation / Lang factor	5	
Total CAPEX estimate	8,500 kEUR.	Indicative screening only, ATEX requirements might CAPEX

Factors for implementation

Congestion

The MVR concept increases the electrical load of the site because the compressor, auxiliaries and control equipment require additional electricity. Based on the screening case, the measure consumes approximately 0.82 MW (COP of 5.2) of electricity. This can be a relevant constraint at sites with limited grid capacity or transformer spare capacity. A site-specific electrical capacity check is therefore required, including the available grid connection, medium-voltage infrastructure, transformer capacity, motor-starting philosophy, redundancy requirements and the possibility of phased or flexible operation.

Retrofitting

Retrofitting an indirect MVR system on DT waste heat requires careful integration with the existing DTDC, vapour handling, condensers and heat recovery system. The main retrofit scope typically includes the MVR compressor, heat exchangers or reboilers, piping tie-ins, condensate handling, controls, safety systems and electrical infrastructure. Brownfield constraints are important because the DTDC area is often space-constrained and may include ATEX zoning due to the presence of hexane-containing streams. The design must also avoid disrupting existing internal heat recovery. Implementation should therefore be based on a detailed heat-source and heat-sink assessment, ATEX review, downtime planning and supplier integration study.

Sustainability and other emissions

The measure reduces fossil steam demand by upgrading DT waste heat to useful process heat. This lowers natural gas consumption and associated direct Scope 1 CO₂ and NO_x emissions from steam generation. The net sustainability benefit depends on the carbon intensity of the electricity used by the MVR compressor. When renewable or low-carbon electricity is available, the measure can provide a significant CO₂ reduction. No significant increase in water emissions is expected, although condensate management, cleaning requirements and possible changes in cooling duty should be checked during the detailed design phase.

Technical maturity

Mechanical vapour recompression and industrial heat-pump concepts are proven technologies in evaporation and heat-upgrading applications.

Possible suppliers

Relevant suppliers for MVR on hexane evaporators or reboilers are mainly found among large international technology providers that design and deliver turnkey oilseed extraction, solvent recovery and miscella-distillation systems. In the vegetable oil industry, this application is often described as vapour recompression, mechanical vapour recompression or MVR-driven miscella distillation. The concept focuses on reusing the latent heat of hexane vapours from the miscella evaporators by compressing these

vapours to a higher pressure and temperature level, so they can be reused as a heating medium for the evaporator or reboiler instead of being fully condensed against cooling water.

Typical supplier categories include oilseed-crushing technology providers such as Desmet, Myande and Anderson International, MVR and distillation specialists such as GEA and Sulzer, compressor suppliers such as Howden/Chart, Piller, Atlas Copco and Everllence, heat-exchanger suppliers such as Alfa Laval and Kelvion, and specialised ATEX/EPC integration partners. Final supplier selection should focus on proven experience with solvent-containing process environments, hexane safety, ATEX compliance, achievable temperature lift, compressor efficiency, integration with existing miscella evaporators and the ability to deliver a complete system

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Depends on use of waste heat.	Low impact
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	Change of hexane volume expected.	Medium; Management of change and ATEX review required

Overall expected permit impact: medium. In combination with measure 1A this measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

The information below should be regarded as an initial point of reference. For advice tailored to your project and circumstances, **please consult RVO's subsidy webpages and have your project proposal reviewed by RVO (project idee toetsen), which offers the opportunity to:**

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- Present your idea and receive feedback
- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes.](#)

Subsidy	Match	Comment
DEI+	Possible match	Could fall under "Overige CO ₂ -reducerende maatregelen" (art. 36). Technical risk is present. Whether this exact configuration already exists in the Netherlands isn't established.
VEKI	Possible match	Could fall under Overige CO ₂ -reducerende maatregelen (art. 36). Mechanical vapour recompression is proven at equipment level, though at least three comparable reference projects would need confirming.
EIA	Highly likely match	Code 270102 [W] "Stoomrecompressie" could fit.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on COP and process-changes

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Possible	When acceptable for client and technically feasible

This installation is implemented as a process-integrated solution. Financing of project costs by an ESCO is possible, depending on the scope allowed by the client, and/or the level of possible collaboration. The relatively large heat flows and clearly measurable utility savings may improve the attractiveness of performance-based contracting compared with smaller heat recovery measures.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the heat pump or indirect MVR system is highly integrated with the DTDC, waste-heat recovery system and steam injection process, individual components such as the compressor package, heat exchangers, drives and auxiliary equipment may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to vapour handling systems, condenser connections, steam injection systems, process piping, controls, instrumentation and ATEX-related equipment. Consequently, the solution is unlikely to be suitable for operational lease financing.

Crushing

Measure 2 (1A + 1B):

MVR on Hexane and DTDC

Summary

Measure 2 combines the concepts described in Measure 1A and Measure 1B. Measure 1A applies MVR to the hexane evaporator or reboiler system in the solvent recovery section, while Measure 1B applies a heat pump or indirect MVR concept to upgrade DT waste heat for reuse in the DTDC. In the standard Crushing factory, these two measures interact because DT waste heat is already used as a heat source for hexane evaporation. The combined measure therefore addresses both systems together, using dedicated vapour recompression concepts to optimise solvent recovery and DTDC heat demand as one integrated configuration. This reduces the dependence on external steam while maintaining the main crushing process route.



Technical description

Existing process

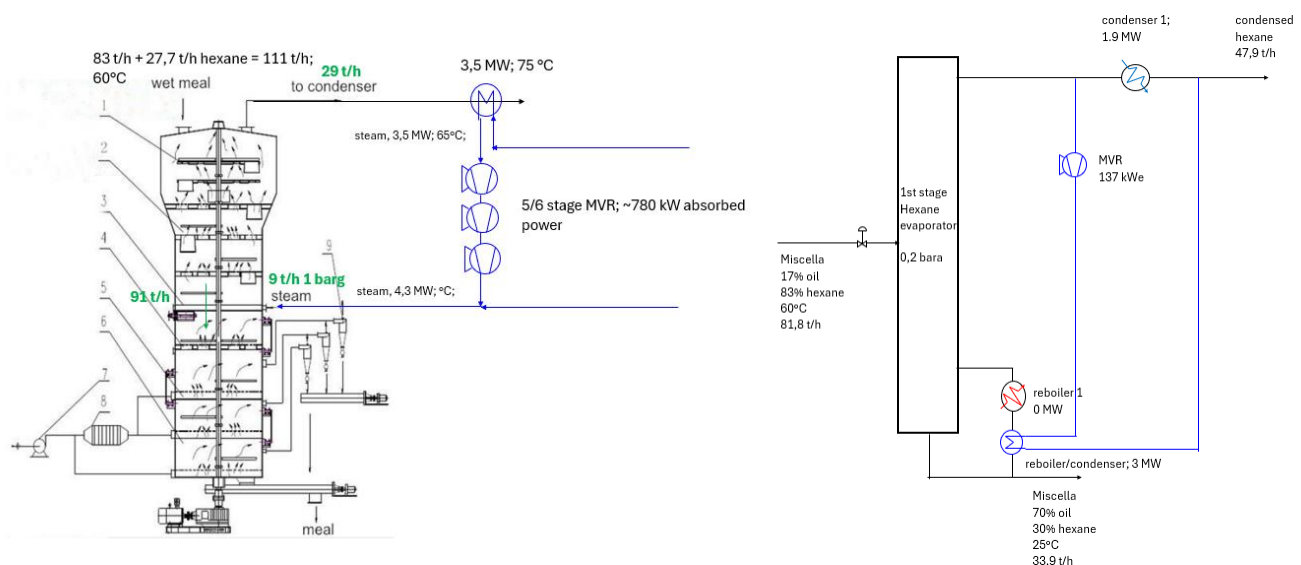
In the standard Crushing factory, DT waste heat is normally used as an internal heat source for hexane evaporation in the solvent recovery system. This means that the DTDC and solvent recovery sections are already thermally connected: heat released from the DT vapours is used to evaporate hexane, while the DTDC itself still requires a substantial amount of direct and indirect steam for desolventising and toasting. As a result, measures that separately target DT waste heat or hexane evaporation cannot simply be added together without considering the interaction between both systems.

New process

This combined measure applies two MVR systems to decouple and optimise the heat integration between DT waste heat and solvent recovery. The first MVR is applied to the hexane evaporation system, allowing hexane evaporation to be driven by recompressed vapour instead of relying on DT waste heat or fresh steam. The second MVR upgrades heat from the DT system so that it can be reused for DT heating duties, replacing a large part of the external steam demand. In this configuration, the heat that is normally used for hexane evaporation is no longer the limiting integration route, because both the solvent recovery and DTDC heat demands are addressed with dedicated vapour recompression concepts.

The combined concept delivers an indicative steam saving of approximately 4.3 MW. Including the avoided boiler losses, this corresponds to approximately 5 MW of natural gas savings. Relative to the reference plant energy basis, this represents an indicative energy reduction of around 26%. The combined system has an indicative COP of 4.1 and compared with natural gas a COP of 4.9, reflecting the overall balance between useful heat delivered and additional electrical compressor power required by the two MVR systems.

The indicative CAPEX for the combined measure is approximately **13,500 kEUR**. Final feasibility depends on the detailed DTDC and solvent recovery configuration, available temperature levels, ATEX zoning, compressor selection, electrical capacity, tie-in complexity, downtime window and the extent of existing heat recovery. A site-specific process integration study is required to confirm the final heat balance and avoid double counting with other measures.



Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-5.0 MW		-40,365 MWh/a
Change in electricity	+1.0 MW		+8,284 MWh/a
Total change in energy	-4.0 MW	-26%	-32,081 MWh/a
CO ₂ emissions Scope 1			-8,167 ton/a

The change in natural gas is calculated based on the reduction of steam demand with a boiler efficiency of 90%

CAPEX	Indicative	Remark
Main equipment	~2700 kEUR for main equipment	Compressors, reboilers, heat exchangers, pumps, controls and/or vendor package
Installation / Lang factor	5	
Total CAPEX estimate	13,500 kEUR	Indicative screening only, ATEX requirements might impact CAPEX

Factors for implementation

Congestion

The combined MVR concept increases the electrical load of the site because two vapour recompression systems, including compressors, auxiliaries and controls, are installed which together use approximately 1 MW of electrical power. This can create a relevant congestion risk at sites with limited grid capacity, transformer spare capacity or medium-voltage infrastructure. A site-specific electrical capacity check is therefore required, including compressor motor loads, starting philosophy, redundancy, operating flexibility and the potential need for grid or transformer reinforcement.

Retrofitting

Retrofitting the combined concept is more complex than implementing either MVR system separately, because the existing internal heat link between DT vapours and hexane evaporation is changed. The retrofit scope typically includes two MVR compressor packages, heat exchangers or reboilers, vapour and condensate piping, control integration, safety systems, electrical infrastructure and tie-ins to both the DTDC and solvent recovery system. Brownfield constraints are important, especially because both areas may be space-constrained and subject to ATEX requirements due to hexane-containing streams. The design must maintain stable DTDC operation, solvent recovery performance and product quality during and after implementation.

Sustainability and other emissions

The measure significantly reduces fossil steam generation by replacing a large part of the DTDC and solvent recovery steam demand with electrically driven MVR systems. The indicative natural gas saving is approximately 5 MW when avoided boiler losses are included, resulting in a substantial reduction of direct Scope 1 CO₂ and NO_x emissions. The net CO₂ benefit depends on the electricity mix used for the compressors; the reduction is highest when renewable or low-carbon electricity is available. No significant

increase in water emissions is expected, although condensate routing, cooling-system impacts and cleaning requirements should be confirmed during detailed design.

Technical maturity

Mechanical vapour recompression is a proven technology in evaporation and industrial heat-upgrading applications.

Possible suppliers

Potential suppliers include vendors and integrators with experience in MVR compressors, solvent recovery, DTDC systems, heat exchangers and ATEX-compliant brownfield integration. Relevant supplier categories include GEA, Howden/Chart, Piller, Atlas Copco, Everllence, Alfa Laval, Kelvion, Desmet, Crown, CPM and specialised ATEX/EPC parties. Final supplier selection should focus on references in oilseed processing or solvent-containing process environments, achievable temperature lift, compressor efficiency, ATEX compliance, service support and the ability to deliver an integrated two-MVR retrofit concept.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	Potential limited Increase of hexane volume within in installation	Medium; confirm hexane inventory, pressure levels and safety distances

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified hexane vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

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Subsidy screening

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Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38). Eligibility depends on whether this specific combined configuration (two MVR systems decoupling DT waste heat from hexane evaporation) counts as new for the Netherlands, and whether meaningful risk remains.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). Mechanical vapour recompression is described as proven and technically mature at equipment level, but the specific two-system integration is flagged as needing site-specific validation, so at least three reference projects with a similar configuration are needed for eligibility.
EIA	Highly likely match	The hexane-evaporation could fit code 270102 [W] "Stoomrecompressie". The DT waste-heat side is named "heat pump indirect MVR"; if it compresses process vapour it could also fall under 270102, but if it uses a separate refrigerant in a closed loop it would instead need to meet code 221103's halogen-free-refrigerant and COP/temperature-lift requirements.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on COP and process-changes

Financial options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Possible	When acceptable for client and technically feasible

This installation is implemented as a process-integrated solution. Financing of project costs by an ESCO is possible, depending on the scope allowed by the client, and/or the level of possible collaboration.

The installation can potentially be removed as a standalone unit without significant consequences for the building or the production line. While the combined MVR system is highly integrated with both the DTDC and solvent recovery processes, individual components such as the compressor packages, heat exchangers, drives and auxiliary equipment may retain residual value and could potentially be recovered and redeployed. However, removal would require substantial modifications to the DTDC heat-recovery system, hexane evaporation system, vapour and condensate piping, controls, instrumentation, electrical infrastructure and ATEX-related equipment. Consequently, the solution is unlikely to be suitable for operational lease financing.

Crushing

Measure 3: Vapour Recovery System: Reuse DC energy to DT

Summary

A Vapour Recovery System (VRS) improves the heat integration within the DTDC system by reusing energy from the drying/cooling section in the desolventising/toasting section. In the existing process, part of this energy is often rejected or only partly recovered, while the DT section still requires external steam to remove solvent and condition the meal. By redirecting this available energy internally, the measure can reduce the external heat demand of the DTDC without fundamentally changing the main process route. The measure is commercially available for suitable DTDC configurations, but its practical applicability depends on the installed equipment, available space, ATEX requirements, existing heat recovery and supplier-specific retrofit options.



Technical description

Vapour Recovery System (VRS) is a Crown / CPM Crown technology for improving solvent and heat recovery in the DTDC system. The measure is not located in the drying/cooling section but consists of an additional tray installed below the DT section. This tray operates with an ejector or thermal vapour recompression vacuum system, which extracts additional steam and solvent vapours from the product. These vapours are then recovered and reused in the DT section, reducing the amount of external steam required for desolventising and toasting while improving internal heat and solvent recovery within the DTDC.

For the standard Crushing factory, this measure has an indicative energy-saving potential of approximately 400,000 m³ of natural gas, equal to about 3% of the reference plant energy basis. The technology is considered commercially available and technically relevant for soybean crushing plants, but its feasibility depends strongly on the existing DTDC configuration, age, available space below the DT section, and the extent to which steam and solvent vapours can be effectively recovered and reused. Main implementation aspects include brownfield tie-ins, ATEX and safety review, integration of the ejector or thermal vapour recompression vacuum system, control integration and maintaining product quality.

The indicative payback period is estimated at approximately 7–10 years and should be further validated based on supplier input and site-specific process data. This suggests that the measure may be most attractive when integrated into greenfield projects, major DTDC upgrades or brownfield modifications where sufficient space and suitable tie-in points are available below the DT section. For brownfield applications, retrofit complexity, vacuum-system integration, ATEX requirements and site-specific constraints may make it more challenging to achieve a sufficiently attractive business case.

Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	0.44 MW		-3,529 MWh/a
Change in electricity	0		
Total change in energy		approximately 3% of the reference plant.	-3,529 MWh/a
CO ₂ emissions Scope 1			714 ton/a

The change in natural gas is calculated based on the reduction of steam demand with a boiler efficiency of 90%

Measure 3: Vapour Recovery System: Reuse DC energy to DT

CAPEX	Indicative	Remark
Main equipment	Supplier quotation required for a specific case.	
Installation / Lang factor	5	
Total CAPEX estimate	Best guess estimate of ~1,250 kEUR	

Congestion

The VRS measure is not expected to create a large electrical demand compared with MVR or heat-pump measures, because the main saving is achieved through improved internal heat recovery within the DTDC system rather than through large electrically driven compressors. Additional electricity use may be required for fans, dampers, controls, pumps or auxiliary equipment, but this is expected to be relatively limited and case specific. A site-specific electrical capacity check is still recommended, especially where fan upgrades, additional control equipment or other auxiliary systems are included in the supplier scope.

Retrofitting

Retrofitting VRS requires integration with the existing DTDC, especially the drying/cooling and desolventising/toasting sections. The retrofit scope typically includes modifications to vapour or air routing, ducts, heat recovery components, dampers, controls, instrumentation and possible tie-ins to existing condensers or heat exchange equipment. Brownfield feasibility depends strongly on the installed DTDC type, available space, equipment age, access for installation and the extent to which energy from the drying/cooling section is already reused. Because the system is linked to hexane-containing process areas, ATEX zoning, explosion safety, solvent containment and shutdown planning must be reviewed carefully with the supplier.

Sustainability and other emissions

The VRS measure reduces the external steam or heat demand of the DTDC by reusing energy that would otherwise be rejected from the drying/cooling section. This lowers natural gas consumption in the boiler system and therefore reduces direct Scope 1 CO₂ and NO_x emissions. Because the measure mainly improves internal heat integration, it does not introduce a major new energy carrier. No significant change in water emissions is expected, although condensate handling, cooling duty and solvent recovery performance should be checked during detailed design. The measure may also reduce solvent losses when implemented as part of an optimised Crown/Schumacher DTDC configuration.

Technical maturity

VRS is a commercially available Crown / CPM Crown technology for DTDC systems and is therefore considered mature at equipment and supplier-package level. The main maturity question is not the technology itself, but its applicability to a specific existing DTDC configuration. Feasibility depends on whether the site has a suitable Crown/Schumacher DTDC or a compatible configuration, whether sufficient recoverable energy is available from the drying/cooling section, and whether the existing process can accommodate the required ducting, controls and heat-recovery integration. Supplier validation is required to confirm performance, solvent safety, product quality and retrofit compatibility.

Possible suppliers

The primary supplier for this measure is Crown / CPM Crown, because VRS is described as a Crown technology for the Crown/Schumacher DTDC. Other suppliers that might offer comparable technology are Desmet, Alfa Laval and Buss SMS Canzler

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x due to reduction of natural gas demand	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Not expected	Not applicable
Odor	None	Not applicable
Application of hazardous media	No change	Low to medium; ATEX and HAZOP review required
External safety	Potential increase hexane volume within in installation	Medium; confirm inventory, pressure levels and safety distances

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

The information below should be regarded as an initial point of reference. For advice tailored to your project and circumstances, **please consult RVO's subsidy webpages and have your project proposal reviewed by RVO ([project idee toetsen](#))**, which offers the opportunity to:

- Discuss the feasibility of your idea and its likelihood of success
- Present your idea and receive feedback
- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Highly likely no match	Could fall under Energy efficiency (art. 38). The source frames the only real open question as configuration compatibility. This is a routine fit rather than genuine remaining technical or economic risk.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). Described as commercially available and mature at equipment and supplier-package level.
EIA	Highly likely match	Code 270102 [W] "Stoomrecompressie" could fit.
SDE++	Highly likely match	MVR's are within the SDE-scheme, depending on COP and process-changes

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Unlikely	

The financing requirement is too low to warrant external financing.

Crushing

Watch list

Summary

Several measures outside the Crushing top 5 are not included because they are less relevant as practical energy-saving measures for implementation before 2030, or because they are already covered by the selected top 5. The watch list for Crushing is therefore limited to measures that are strategically interesting but do not yet have the required technology readiness level, industrial proof, or regulatory certainty for inclusion in the practical top 5. For Crushing, this concerns M16 alternative solvents, M17 membranes for hexane extraction and M18 mechanical pressing to remove hexane from extracted flakes.

The watch-list measures should not be interpreted as low-value options. Instead, they represent technologies or process changes that may become relevant in the longer term, especially if legislation, solvent restrictions, product requirements or technology development change the boundary conditions for soybean extraction. Their main value is therefore strategic: they should be monitored, assessed in innovation projects and reconsidered when regulatory or technical developments make implementation more realistic.



M16 – Alternative solvents is included on the watch list because future legislation may restrict or phase down the use of conventional extraction solvents such as hexane. If alternative solvents, for example ethanol, become mandatory or commercially preferred, the extraction and solvent recovery system would need to be redesigned or significantly modified. Such a change would not primarily be implemented as an energy-saving measure, but it could create an important opportunity to integrate energy-efficient technology at the same time. If a new solvent recovery system must be installed, mechanical vapour recompression could be incorporated directly into the new design. This could reduce the additional energy demand associated with solvent recovery and improve the overall business case of the regulatory-driven investment. For this reason, alternative solvents are considered strategically important, even though they are not yet a practical short-term energy-saving measure for the standard Crushing factory.

M17 – Membranes for hexane extraction has a potentially high theoretical energy-saving potential because membrane separation could reduce the thermal load in solvent recovery. In principle, membranes could separate oil, solvent or miscella fractions with less evaporation duty, thereby lowering steam consumption in the evaporators and reboilers. However, the technology is not yet proven at the required industrial scale for soybean crushing. Important uncertainties remain around membrane selectivity, flux, fouling behaviour, cleaning requirements, compatibility with hexane-containing streams, lifetime, yield impact and integration in a continuous extraction process. Because of these uncertainties, M17 is not suitable for the practical top 5, but it remains relevant as an innovation or demonstration topic.

M18 – Mechanical pressing to remove hexane from flakes aims to reduce the amount of solvent carried with the extracted flakes into the DTDC. In principle, this could reduce the steam demand for desolventising and thereby lower the heat demand of one of the largest energy users in the Crushing reference plant. However, the concept introduces significant technical and safety concerns. Mechanical handling or pressing of hexane-containing flakes may create ATEX and ignition risks, and the technology is not yet proven as a robust industrial solution in this application. Additional uncertainties include mechanical reliability, solvent containment, product quality, maintenance, and integration with the extractor and DTDC. For these reasons, M18 is retained as a watch-list concept only.

Overall, the Crushing watch list focuses on longer-term developments rather than immediately implementable energy-saving projects. M16 is mainly driven by potential future solvent legislation and may become relevant if a major solvent-system redesign is required. M17 and M18 are technically interesting because they could reduce solvent recovery or DTDC heat demand, but both require further industrial validation before they can be considered broadly applicable. These measures should therefore be monitored through technology development, regulatory developments, supplier innovation and potential pilot or demonstration projects.

Crushing

Longlist

Summary

The FAME/biodiesel longlist provides an overview of potential energy-saving measures for the standard FAME/biodiesel factory. The measures mainly focus on reducing steam demand in methanol recovery, glycerol/methanol separation and FAME polishing, as these thermal separation steps dominate the energy balance. Additional options include improvements to phase separation, vacuum generation and alternative recovery concepts. The longlist is intended as a screening tool to compare measures on indicative energy-saving potential, expected payback and technical applicability before selecting the most promising options for further elaboration.



Measure 3: Vapour Recovery System: Reuse DC energy to DT

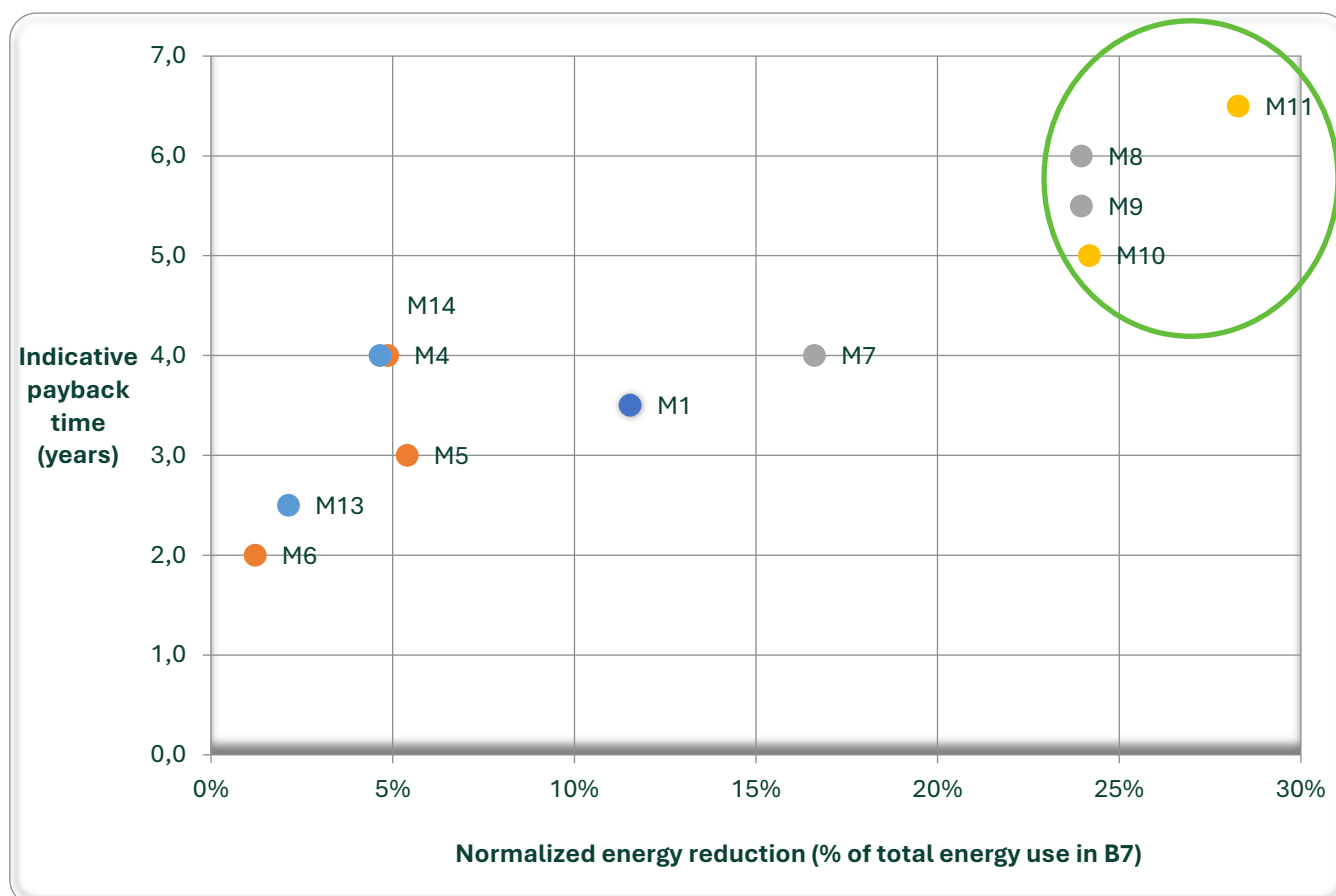
#	# M	Measure	Process step	Indicative saving	Basis / remark
1		Seed preheater using heat integration	Pretreatment / conditioning	98,582 GJ/y	Residual heat preheating up to approximately 70°C; dependent on available waste heat.
2		Reuse hot air in dehulling	Pretreatment	n/a	Requires air cleaning and is expected to have limited feasibility because dryer outlet air is only around 40°C.
3		Increase size of cracking/flaking units	Mechanical	Case-specific	Mainly electrical savings, expected to be limited.
4		Optimize hexane/feed ratio	Extraction	41,472 GJ/y	Reduces solvent recovery and DTDC load but must protect extraction yield.
5		Efficient draining / Quickdrip	Extraction	46,080 GJ/y	Reduces hexane carryover to DT and therefore steam use.
6		Improved extractor control	Extraction	10,368 GJ/y	Small operational saving through improved filling and residence time.
7	M 3	VRS: reuse energy from DC to DT	DT/DC	141,811 GJ/y	Commercially available, but applicability depends on DTDC configuration and age.
8	M 1 B	Heat pump or indirect MVR on DT waste heat	DT/DC	204,595 GJ/y	Strong potential but must avoid double counting because DT waste heat may already be reused.
9		MVR on DT steam / TVR alternative	DT/DC / utilities	204,595 GJ/y	Overlaps with M8; direct MVR on DT steam may be constrained by hexane.
10	M 1 A	MVR on hexane evaporator / reboilers	Solvent recovery	206,496 GJ/y	Targets one of the main heat consumers in solvent recovery.
11		Recompression of hexane as heat source	Solvent recovery	241,476 GJ/y	High theoretical saving but overlaps with M10 and has limited use for low-temperature heat.
12		Heat integration around evaporators / miscella recuperation	Solvent recovery	n/a	Fouling and cleaning are key constraints; no kW saving was quantified.
13		Utility and boiler efficiency optimization	Utilities	18,144 GJ/y	Reduces boiler, steam distribution and condensate losses. Some actions may overlap with EML obligations.
14		Heat recovery in drying section	Utilities / drying	39,689 GJ/y	Preheats drying air, especially from 15°C to 35°C.
15		Low-temperature waste heat heat pump	Cooling / heat	0 GJ/y	Excluded because no unsupplied low-temperature heat demand is identified in the reference plant.
16		Alternative solvents	Extraction	0 GJ/y	Mainly sustainability-driven, not an energy-saving measure for the standard case.
17		Membranes for hexane extraction	Extraction	183,456 GJ/y	Theoretical saving, but no industrial demonstration plants and uncertain yield/selectivity.
18		Mechanical press for removing hexane from flakes	Extraction / safety	n/a	Excluded due to ATEX risk and lack of proven applications.

Top 5 selection

The figure shows why the selected Crushing measures focus mainly on the dominant thermal energy users and heat-integration opportunities in the reference plant. The largest relevant heat demands are linked to the DTDC, solvent recovery evaporators, drying and conditioning, and the utility system. At the same time, several process streams contain substantial residual heat, including DTDC waste heat, evaporator condenser heat, dryer air and product streams. These streams provide opportunities for heat recovery, heat upgrading, mechanical vapour recompression and improved process integration.

The selected measures therefore target the main Crushing energy users and heat sources shown in the figure. M10 focuses on mechanical vapour recompression in the hexane evaporator and reboiler system, where solvent recovery represents a major heat-integration opportunity. M8 addresses the upgrading of DT waste heat by means of a heat pump or indirect MVR concept, provided that the heat source is sufficiently continuous and not already fully reused elsewhere in the process. M7 focuses on reusing energy from the drying and cooling section of the DTDC towards the desolventising and toasting section, thereby reducing external steam demand. M1 targets seed preheating using available residual heat before or during conditioning, while M5 reduces hexane carryover to the DTDC through improved draining, directly lowering the downstream desolventising heat requirement.

Measures outside this selection generally have a smaller contribution to the standard-factory energy balance, overlap with selected options or are more site-specific. Examples include additional low-temperature heat recovery, further utility optimisation, extractor control improvements, alternative solvents, membrane-based hexane extraction and other advanced extraction concepts. These options may still be relevant for individual sites, but they are considered less suitable for the practical top five because of lower direct savings, technology maturity, retrofit risk, safety considerations or overlap with the selected heat-recovery and solvent-recovery measures.



Selection note

Based on this approach, the selected Crushing measures focus on the most relevant practical themes: reducing steam demand in solvent recovery, upgrading or reusing DTDC waste heat, improving heat integration in pretreatment, and reducing hexane carryover to the DTDC. M10 is selected because solvent recovery is one of the dominant thermal energy users in the reference plant and mechanical vapour recompression on the hexane evaporator or reboilers provides a direct route to reducing fresh steam demand. M8 is selected because DT waste heat represents a large heat source that can potentially be upgraded using a heat pump or indirect MVR concept, although its feasibility depends strongly on whether this heat is already reused elsewhere. M7 is selected because it directly targets the DTDC by reusing energy from the drying/cooling section towards the desolventising/toasting section.

Due to the existing heat integration between the DTDC and the pretreatment section, opportunities for high-impact energy reduction in drying and conditioning are limited. Plants without this heat integration should consider such measures; however, as this integration is regarded as standard practice, related measures are not included in this report.

Reference Plant #3

Refining

Summary

In a reference plant for the refining process, vegetable oil is processed mainly by bleaching and deodorizing. Deodorisation is by far the largest energy consumer.

Major savings in the deodorisation process are limited to replacing the gas boiler with an e-boiler because of the high temperature (160 C) and the existing heat integration. The other proposed measures target low-temperature applications such as degumming and tank storage, and reduction of steam usage by vacuum ejectors by lowering distillation pressure or replacing steam ejectors with electric vacuum pumps.

The energy-saving potential of the individual measures ranges between 5-25% energy; depending on the existing heat integration, total savings of 20-30% are expected.

All measures are proven technology. Permit changes are not expected to be a major issue, and suitable subsidies are available. The e-boiler and possibly tank heating may fit EsCo or operational lease financing; other process-integrated measures are less suitable.



Description reference plant

Production process

The standard Refining factory represents a typical edible-oil refining route and is used as the reference process for the measures assessed in this chapter. The figures below show the reference plant process schematically: crude oil enters the refinery from storage, is conditioned through degumming and/or neutralisation, washed and vacuum dried, treated in the bleaching section, deodorized under high temperature and deep vacuum, and finally cooled and transferred to product storage. These figures provide the visual basis for the process description, the unit-operation overview and the energy analysis that follow.

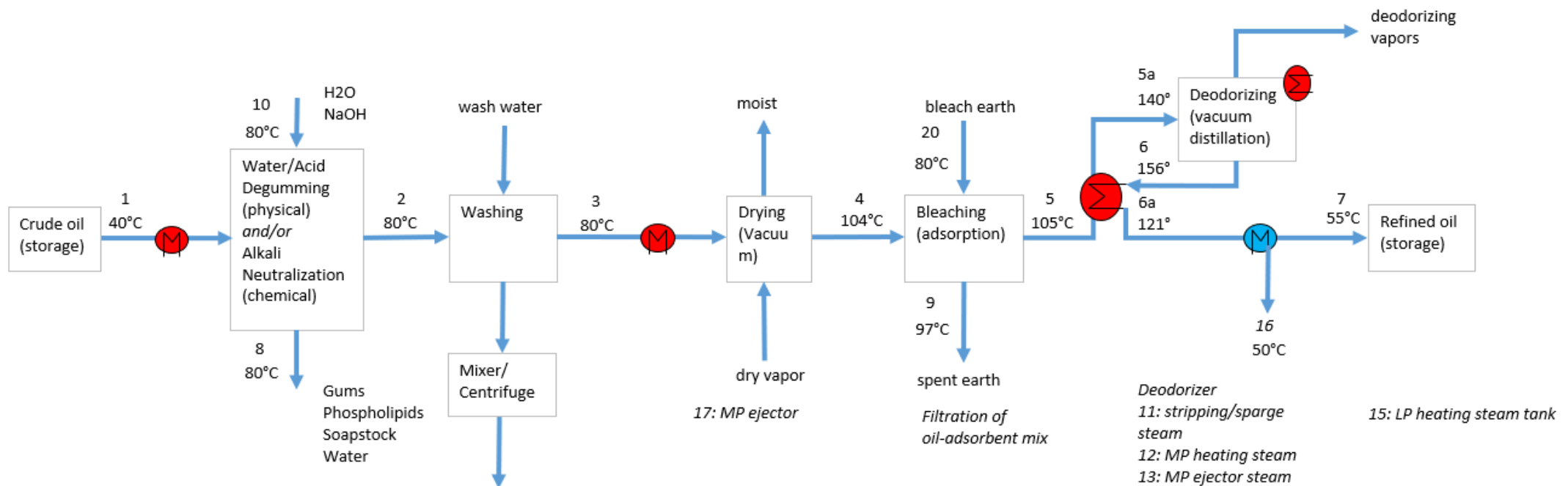
The standard Refining plant represents a multi-oil refinery and can include oils such as soybean, rapeseed, palm, coconut, sunflower and linseed, depending on the site configuration and product portfolio.

Capacity reference plant

Parameter	Value	Unit
Input capacity crude oil	203,460	tonnes/year
Refined oil production capacity	200,000	tonnes/year
Operating hours	8,000	hours/year
Average throughput	600	tonnes/day
Average product flow	25	tonnes/hour refined oil
Crude storage volume	7,500	tonnes crude oil
Average storage time	12.5	days
Soap stock after degumming / neutralization	2,000	tonnes/year
Spent earth after bleaching	2,500	tonnes/year
Overall yield	98.3%	based on input and refined oil output

Process description

- **Crude oil storage and heating:** crude oil is stored in heated tanks.
- **Degumming and/or neutralisation:** gums, phospholipids and free fatty acids are removed or converted. Chemical refining uses caustic soda to form soap stock, while physical refining relies more on degumming and downstream deodorisation.
- **Washing:** residual soaps, salts and impurities are removed with wash water.
- **Vacuum drying:** water is removed from the washed oil before bleaching.
- **Bleaching:** bleaching earth is mixed with the oil to adsorb colour bodies, oxidation products and trace contaminants. The oil is heated before bleaching and filtered afterwards to remove spent bleaching earth.
- **Deodorisation:** bleached oil is heated to deodorisation temperature and treated under deep vacuum with stripping steam. Heat recovery between incoming bleached oil and outgoing deodorized oil is assumed to be largely implemented already.
- **Product cooling and storage:** refined oil is cooled after deodorisation and sent to storage.



Unit operations

Unit operation	Function	Importance for energy analysis
Crude oil storage and tank heating	Storage of crude oil at controlled temperature	Tank heating and tracing are relevant heat users. The reference plant includes approximately 6,000 tonnes/year LP steam for tank heating/tracing, equal to about 444 kW.
Degumming / neutralization	Removal or conversion of gums, phospholipids and free fatty acids	Oil is heated from approximately 40°C to 80°C, with an estimated duty of about 565 kW.
Washing	Removal of soaps, salts and impurities with water	Mainly relevant because wash water and soap stock handling affect downstream drying duty, wastewater and oil losses.
Vacuum drying	Removal of residual water before bleaching	Moisture is reduced from about 0.3 wt% to 0.03 wt%. The calculated evaporative heat is about 43 kW, with additional oil heating from 80°C to 97°C of about 239 kW.
Bleaching	Adsorption of impurities using bleaching earth	Oil is heated from approximately 97°C to 105°C, with an estimated duty of about 112 kW. Spent earth after bleaching is approximately 2,500 tonnes/year.
Deodorization	Removal of FFA, odour compounds and volatile contaminants under high temperature and deep vacuum	Key energy-intensive step. The reference plant includes heating from approximately 105°C to 187°C and from 187°C to 240°C, plus stripping steam and vacuum-related steam demand.
Deodorizer vacuum system	Creation of deep vacuum for steam stripping	Vacuum is typically required in the range of 1 to 5 mbar(a) for deodorization. Steam ejectors or mechanical/dry vacuum systems strongly influence energy use.
Product cooling	Cooling of deodorized oil before storage	Cooling from approximately 135°C to 80°C represents about 764 kW heat removal in the reference plant.

Measure 3: Vapour Recovery System: Reuse DC energy to DT

Process variation

Existing refineries can differ significantly in feedstock type, refining route, storage temperature, oil quality, vacuum system, deodorizer design, heat recovery level and utility configuration. Chemical refining is generally more relevant for oils such as soybean and rapeseed oil, while physical refining is often applied to palm and coconut oil. Some refineries operate batch processes while others operate continuously. In addition, many sites already apply a significant level of heat integration, especially around deodorisation, where incoming bleached oil is preheated with outgoing deodorized oil. This affects the remaining saving potential for additional heat recovery and electrification measures.

Mass and energy balance

Energy / utility	Value	Unit	Remark
Storage / tank heating and tracing	444	kW	Based on approximately 6,000 tonnes/year LP steam, or 30 kg LP steam/t oil.
Heating before degumming / neutralization	565	kW	Oil heating from approximately 40°C to 80°C.
Vacuum drying, evaporative heat	43	kW	Water removal from washed oil.
Heating before drying	239	kW	Oil heating from approximately 80°C to 97°C.
Heating before bleaching	112	kW	Oil heating from approximately 97°C to 105°C.
Deodorizer MP heating steam	413	kW	Net MP heating steam duty in the reference plant.
Deodorizer high-temperature HP heating steam	736	kW	Heating from approximately 187°C to 240°C.
Deodorizer HP motive steam	185	kW	HP steam related to vacuum generation in the reference plant balance.
Deodorizer stripping / sparging steam	74	kW	LP steam for stripping/sparging.
Product cooling after deodorization	764	kW	Cooling deodorized oil from approximately 135°C to 80°C. This is cooling demand, not primary heat demand.
Total heat in the factory	2,800	kW	Excluding heat recovery
Total reference plant heat demand	2,300	kW	80% heat recovery over the deodorizer demand
Total natural gas demand	2,494	Kw	Boiler efficiency of 92%

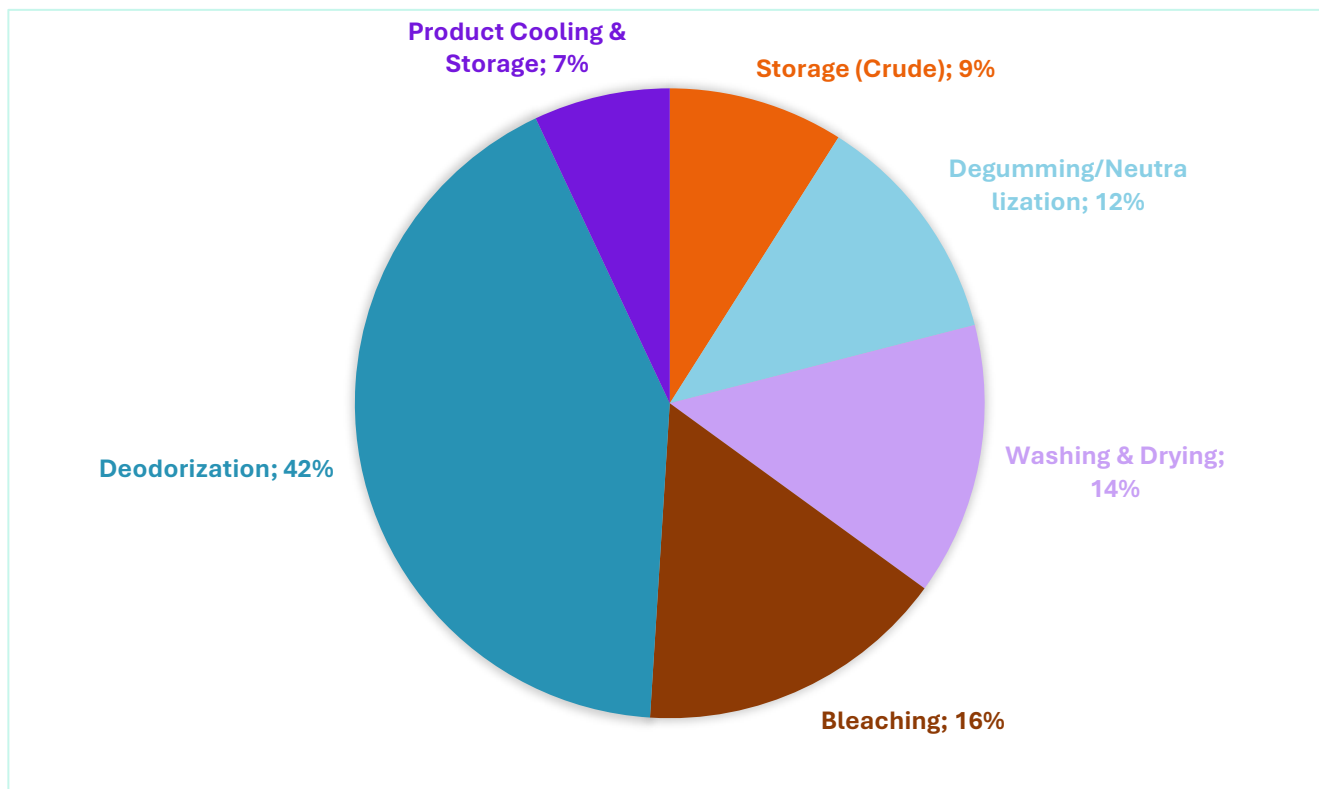
The total heat demand of the standard Refining factory is approximately **24,000 MWh/a**, based on a fossil energy consumption of 2.5 MW and 0.5 MW electrical. This value is used as the denominator for the percentage energy-saving potential of Refining measures.

Energy analysis

Based on sector input the electricity use of the unit operations has been set to 16% of the unit operations' total energy use. The electricity consumption of 16% clearly indicates that the main energy consumption in the plant is thermally driven. Deodorisation is the most important individual energy user because it combines high-temperature heating, deep vacuum and stripping steam. Storage and tank heating are also relevant, particularly for oils that require elevated temperatures to remain pumpable.

The reference plant assumes that a significant part of basic heat recovery is already been implemented, especially around the deodorizer, where incoming bleached oil is preheated with outgoing deodorized oil.

The most relevant energy-saving themes for Refining are therefore: reducing LP steam demand for tank heating, tracing and low-temperature oil heating; replacing or improving steam-based vacuum systems; recovering or upgrading residual heat from product cooling and other low-temperature streams; and improving deodorizer energy performance. Product cooling and storage should also be considered an energy user, because it is related to cooling deodorized oil before storage and maintaining suitable storage conditions. Although this is mainly a cooling or heat-rejection duty rather than a primary heat demand, it still requires utilities, pumps and temperature control, and can provide a useful heat source for residual-heat recovery or heat-pump integration. Measures such as residual-heat use, heat pumps, dry vacuum systems, e-boilers and deodorizer vacuum upgrades should therefore be evaluated carefully against site-specific steam systems, heat integration, electricity availability, product storage requirements and retrofit constraints.



Top 6 measures

The top five were selected following a review meeting with the Oils and Fats sector. Measures were prioritised where they address a clearly present energy user in the reference plant, have a realistic route to implementation before 2030, can be applied in existing brownfield refineries, and offer a sufficiently concrete basis for further technical and business-case development.

Based on this approach, the selected Refining measures focus on the most relevant practical themes: deodorizer energy performance, vacuum-system improvements, residual-heat use for tank and oil heating, and electrification of low-temperature heat demand. These measures are considered the most suitable candidates for further elaboration in the VIBE Navigator, while final feasibility should still be confirmed with site-specific heat balances, vacuum-system data, electricity constraints, supplier input and retrofit assessments.

#	Measure	Indicative saving	Relative saving	Pay back time	Selection rationale
1	E boiler to replace 70 bar steam	1,034 MWh/a	4%	10-15 yrs	Natural gas boiler has an efficiency of 85% at 70 bar steam pressure. Therefore, energy saving of the E-boiler is bigger compared to low pressure E-boilers.
2	Heat oil for degumming / neutralization with residual heat or heat pump	3,496 MWh/a	15%	5-10 yrs	Targets a clear low- to medium-temperature heat demand and can reduce steam use if a suitable residual-heat source is available.
3	Tank heating with residual heat / heat pump	2,668 MWh/a	11%	5-10 yrs	Relevant across refineries with heated tanks and tracing. The measure can reduce LP steam demand, especially for higher-melting oils and long storage times.
4	Heat pump to produce LP steam for utilities	6,661 MWh/a	28%	10-15 yrs	High theoretical saving but selected for further screening rather than direct implementation.
5	Dry vacuum pumps instead of steam ejectors for the deodorizer	2,131 MWh/a	9%	10-15 yrs	Selected because supplier cases indicate meaningful combined savings when dry pumps, improved condensing and additional deodorizer heat recovery are implemented together.
6	Chilled condensing to reduce motive steam consumption	-3,509 MWh/a	15%	5-10 yrs	Significant energy saving potential depending on design.

Refining

Measure 1: E-boiler for 70 bar steam

Summary

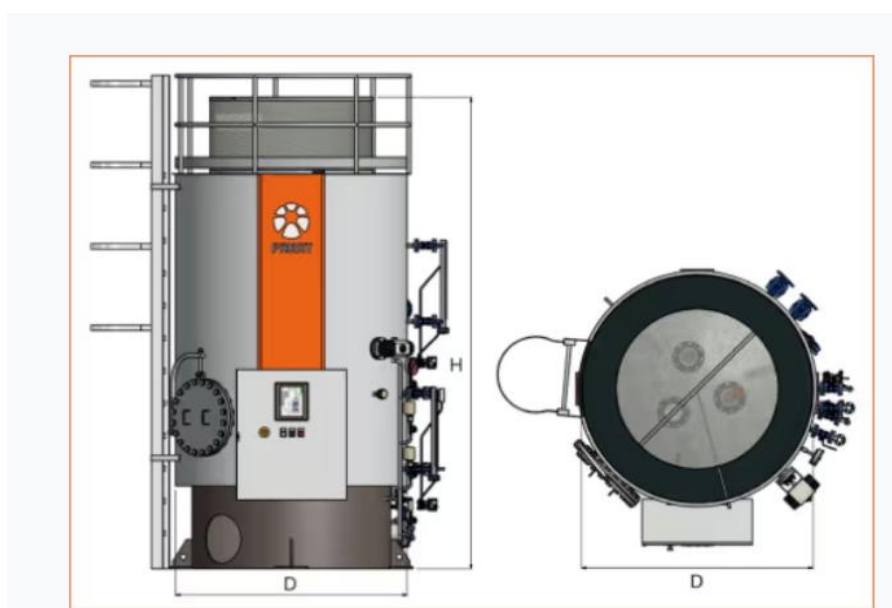
This measure replaces high-pressure steam production for deodorizer heating with a high-pressure electrode e-boiler. In the existing situation, 70 bar(g) steam is produced in a gas-fired boiler with an efficiency of approximately 85%, partly due to the high steam temperature and resulting high stack temperature. The e-boiler produces the required high-pressure steam electrically at approximately 99% efficiency, reducing natural gas use and Scope 1 CO₂ emissions, but increasing electricity demand. Final feasibility depends strongly on electricity price, grid capacity, connection costs, operating strategy and whether hybrid operation with the existing boiler remains possible.



Technical description

In the existing process, high-pressure steam is produced at approximately 70 bar(g) to supply heat to the deodorizer. The reference case assumes a steam production of around 1.8 t/h and an average thermal demand of approximately 0.77 MWth. Because the gas-fired high-pressure boiler operates at around 85% efficiency, replacing this duty with an electrode e-boiler can reduce primary fuel use. The proposed new process uses a medium-voltage electrode e-boiler, for example at 10 or 20 kV, with a capacity above 2 MW and an efficiency of around 99%. Reverse osmosis feedwater treatment is required for the electrode-type boiler. A hybrid concept with the existing gas boiler and dynamic electricity pricing may be considered but should be assessed site-specifically.

The figure below provides an example of a high-pressure electrode e-boiler system and illustrates the main equipment configuration that may be required for this measure.”



Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-0.91 MW	33%	-7,244 MWh/a
Change in electricity	+0.78 MW	+150%	+6,209 MWh/a
Total change in energy	-0.129 MW	-4%	-1,034 MWh/a
CO2 emissions Scope 1			-1,466 ton/a

The change in natural gas is based on the reduction of steam or heat demand.

CAPEX	Indicative	Remark
Main equipment	20 kV e-boiler, 2 MW – 1,250 kEUR	High voltage boiler required
Installation factor	Lang factor 3.5	
Total CAPEX estimate	Total installed CAPEX: 4,400 kEUR	Indicative screening only

Factors for implementation

Congestion

The e-boiler adds a significant electrical load of approximately 0.78 MW on average, and the installed capacity is expected to be above 2 MW. This may create grid-capacity constraints or require a larger electrical connection, medium-voltage infrastructure and additional transformer capacity. A site-specific grid impact analysis is therefore essential. Hybrid operation with the existing gas boiler can reduce operational risk and may provide flexibility during periods of high electricity prices or limited grid availability.

Retrofitting

Implementation requires integration of a high-pressure electrode e-boiler into the existing steam system, including tie-ins to the 70 bar(g) steam header, feedwater treatment, electrical infrastructure, controls, safety systems and possible modifications to the boiler house. Space availability, downtime requirements, pressure-equipment compliance and interaction with the existing gas boiler must be assessed. Retaining the existing boiler as backup or for hybrid operation can reduce operational risk.

Sustainability and other emissions

The measure reduces natural gas consumption and therefore lowers direct Scope 1 CO₂ emissions by approximately 1,466 t/a. NO_x emissions from the gas-fired boiler are expected to decrease as less natural gas is combusted. No significant change in water emissions is expected, although reverse osmosis feedwater treatment introduces additional water treatment requirements. The overall climate benefit depends on the electricity emission factor and the procurement of renewable or low-carbon electricity.

Technical maturity

High-pressure electrode boilers are commercially available and technically mature for industrial steam production. The main uncertainty is not technology readiness, but the business case and site integration. Key points to validate include high-pressure steam demand profile, electrical connection capacity, medium-voltage integration, feedwater quality, control philosophy, redundancy requirements and the feasibility of hybrid operation.

Possible suppliers

Potential suppliers include vendors of industrial electrode boilers and high-pressure steam systems, such as PARAT, Zander & Ingeström, Bosch Industrial, Precision Boilers, AC Boilers and other medium-voltage e-boiler suppliers. Final supplier selection should be based on 70 bar(g) steam capability, electrode boiler references, feedwater requirements, electrical integration and service support.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x due to reduction of natural gas demand	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Not expected	Not applicable
Odor	None	Not applicable
Application of hazardous media	No change	Low to medium; ATEX and HAZOP review required
External safety	None	Low

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

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- Discuss the feasibility of your idea and its likelihood of success
- Present your idea and receive feedback
- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Highly likely no match	E-boilers are a proven technology, therefore this measure is likely not subsidised under DEI+.
VEKI	Highly likely match	Could fall under Overige CO ₂ -reducerende maatregelen (art. 36): net energy changes little, since added electricity nearly offsets the avoided gas, this is a fuel-switch reducing CO ₂ intensity.
EIA	Highly likely match	Code 270104 [W] "Elektrische toestellen voor stoomopwekking..." could fit: an electric device generating steam, replacing a gas-fired boiler, exactly matching this measure. The code explicitly also covers hybrid electricity/gas setups, relevant since hybrid operation is mentioned here.
SDE++	Highly likely match	E-boilers eventually combined with high-temperature-storage are within the SDE-schema. There is a category Opex-only for existing E-boilers within the SDE-scheme.

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Likely	Operational lease
External ownership & operation (ESCO)	Likely	

This installation is implemented as a standalone unit or utility. Financing of project costs by an ESCO is well feasible, depending on the project scale, the scope allowed by the client, and/or the level of possible collaboration.

The installation can easily be removed as a standalone unit without significant consequences for the building or the production line. While the high-pressure electrode e-boiler is integrated with the site's steam distribution system, it functions primarily as a utility asset rather than as process-specific equipment. Individual components such as the boiler vessel, electrodes, transformers, switchgear and auxiliary equipment retain residual value and can generally be recovered and redeployed at other industrial sites. However, removal would require modifications to steam-header connections, electrical infrastructure, feedwater systems and control interfaces. Consequently, the solution is well suited for operational lease financing.

Refining

Measure 2: Heat oil for degumming / neutralisation with residual heat or heat pump

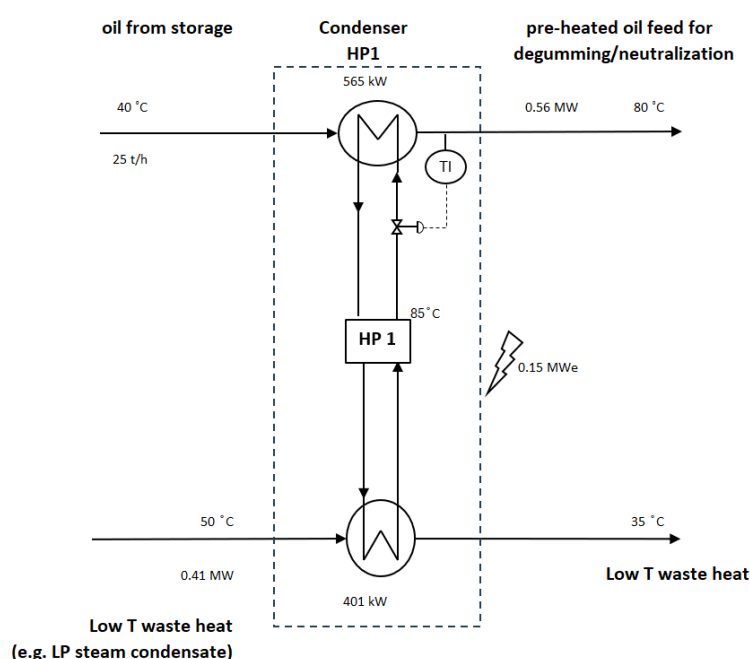
Summary

This measure replaces high-pressure steam production for deodorizer heating with a high-pressure electrode e-boiler. In the existing situation, 70 bar(g) steam is produced in a gas-fired boiler with an efficiency of approximately 85%, partly due to the high steam temperature and resulting high stack temperature. The e-boiler produces the required high-pressure steam electrically at approximately 99% efficiency, reducing natural gas use and Scope 1 CO₂ emissions, but increasing electricity demand. Final feasibility depends strongly on electricity price, grid capacity, connection costs, operating strategy and whether hybrid operation with the existing boiler remains possible.



Technical description

This measure focuses on replacing part of the steam demand for low- and medium-temperature oil heating before degumming and/or neutralisation with residual heat and heat pump integration. In the standard Refining factory, oil is heated from approximately 40°C to 80°C before degumming or neutralisation, with an indicative duty of about 565 kW. Where sufficient residual heat is available from other refinery process steps, this heat can be recovered directly or upgraded with a heat pump to the required temperature level. The measure reduces fossil steam or natural gas demand, but may increase electricity consumption for the heat pump, circulation pumps and controls. The final saving potential depends on the available heat source, required oil-heating temperature, operating hours, heat-pump COP, integration with existing heat exchangers and site-specific retrofit constraints.



Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-0.589 MW	-21%	-4,710 MWh/a
Change in electricity	+0.152 MW	+27%	+1,214 MWh/a
Total change in energy	-0.437 MW)	-14.5%%	-3,496 MWh/a
CO ₂ emissions Scope 1			-953 ton/a

The change in natural gas is based on a reduction in steam or heat demand. Additional electricity must be incorporated into the site-specific business case and grid impact analysis.

Measure 2: Heat oil for degumming / neutralisation with residual heat or heat pump

CAPEX		Remark
Main equipment cost total	200 kEUR	Heat exchangers (75 kEUR) Heat pump water-water including HFO encasing excl spared (125 kEUR)
Lang factor	6	
CAPEX	1,200 kEUR	

Factors for implementation

Congestion

The measure can increase electrical load when a heat pump is used. The expected additional demand is moderate compared with high-temperature electrification measures, but it may still require verification of available connection capacity, MCC capacity, transformer loading and cable routes. If direct residual heat recovery without a heat pump is feasible, the grid impact is limited to circulation pumps and controls. Hybrid operation with the existing steam heater is recommended to reduce operational risk during grid limitations, maintenance or periods with unfavourable electricity prices.

Retrofitting

Brownfield implementation requires integration with the existing oil preheating system, including additional heat exchangers, heat-pump skid or residual-heat loop, circulation pumps, control valves, instrumentation and tie-ins to the oil line and utility systems. Space availability, hygienic design, cleanability, product quality, pressure drop and temperature control must be checked. The measure is preferably implemented as a parallel or hybrid heating route, so the existing steam heater can remain available for start-up, peak demand, product changes and fallback operation.

Sustainability and other emissions

Water emissions are not expected to change significantly, because the measure mainly affects heat supply to the oil preheating step and does not change the degumming or neutralisation chemistry. The measure reduces natural gas consumption by approximately 4,710 MWh/a, corresponding to an indicative Scope 1 CO₂ reduction of approximately 953 tonnes CO₂/a. NO_x emissions from the gas-fired boiler are also expected to decrease as less natural gas is combusted. If an additional closed water or glycol loop is introduced, this should be included in the site's maintenance and leak management procedures. The net climate benefit should also account for the additional electricity demand of the heat pump and the applicable electricity emission factor.

Technical maturity

The individual technologies are mature: plate or shell-and-tube heat exchangers, residual-heat loops and industrial heat pumps are commercially available. The main uncertainty is the process integration rather than the technology itself. Technical validation should focus on the heat-source profile, minimum approach temperatures, oil-side fouling, controllability, product quality, heat-pump COP, operating hours and interaction with existing heat recovery. The measure is therefore suitable for

Measure 2: Heat oil for degumming / neutralisation with residual heat or heat pump

feasibility screening and can be developed further with vendor input and site-specific heat balance data.

Possible suppliers

Potential suppliers include heat exchanger and edible-oil process suppliers such as Alfa Laval, GEA, SPX Flow, Kelvion, API Heat Transfer and HRS Heat Exchangers, as well as industrial heat-pump suppliers such as Johnson Controls/Sabroe, Everllence, Atlas Copco, Howden/Chart, GEA Heating & Refrigeration and other specialised high-temperature heat-pump vendors. Final supplier selection should be based on temperature lift, oil-side design, food-grade requirements, cleanability, references, refrigerant choice, ATEX requirements and service support.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x due to reduction of natural gas demand	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors of heat pump. Can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	None	Low

Overall expected permit impact: medium. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment, compressor noise and modified vapour handling. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

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- Identify any additional subsidies that may be relevant to you

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#).

Subsidy	Match	Comment
DEI+	Most likely no match	Proven technology therefore likely not subsidised under DEI+
VEKI	Highly likely match	Could fall under Energy efficiency (art. 38). Heat exchangers and industrial heat pumps are mature, commercially available technology, supporting the proven-technology requirement, though at least three comparable reference projects for this specific application would need confirming.
EIA	Possible match	If a heat pump is used, code 221103 [W] "Warmtepomp" could apply, requiring a halogen-free refrigerant and a minimum COP set by the temperature lift between heat source and delivery. The permit section points toward ammonia or hydrocarbon refrigerants, both halogen-free, but the minimum COP needs to be met too.
SDE++	Possible match	Closed heat pumps are within the SDE-scheme. Minimum COP 2.3. only halogen-free refrigerants.

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Unlikely	

The financing requirement is too low to warrant external financing.

Refining

Measure 3: Tank heating with residual heat / heat pump

Summary

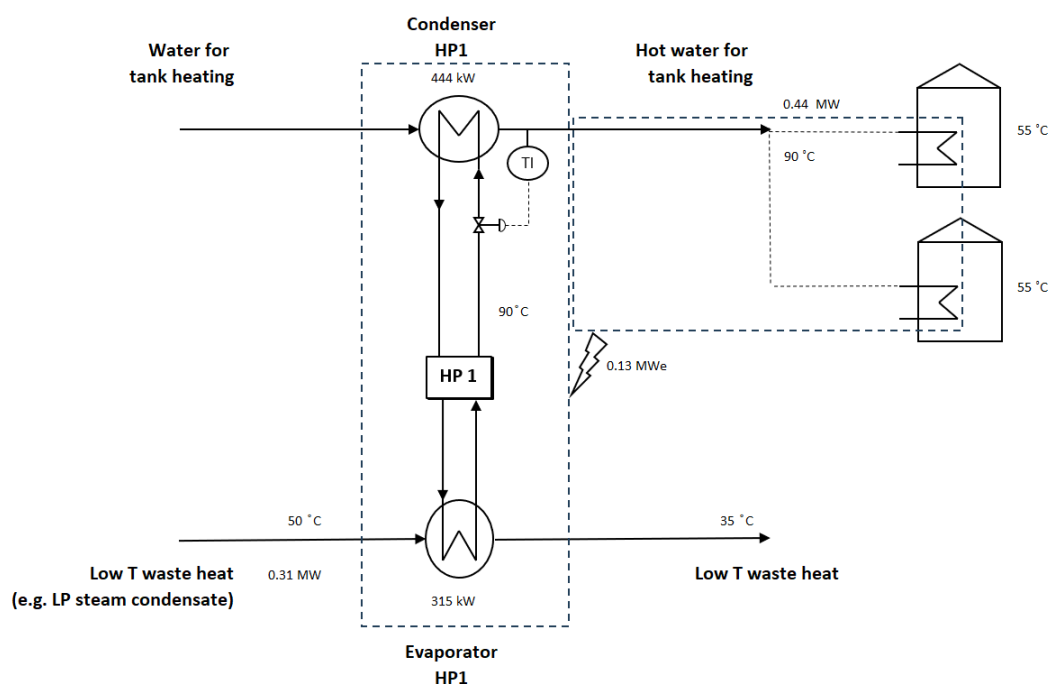
This measure reduces LP steam demand for crude-oil storage tanks, product tanks and pipe tracing by using available residual heat directly, or by upgrading residual heat with a heat pump. In the standard Refining factory, tank heating and tracing represent approximately 444 kW of thermal demand and are based on around 6,000 tonnes/year of LP steam. The measure is especially relevant for oils and fats that must be kept above their melting or crystallization temperature, such as palm oil, coconut oil or other higher-melting feedstocks.



Technical description

In the existing situation, LP steam is typically supplied to tank coils, external heat exchangers, heating jackets and pipe tracing to maintain crude oil, intermediate oil or product tanks at the required storage and pumping temperature. This heat demand is often continuous or semi-continuous and can therefore be suitable for low-temperature heat recovery. In the proposed configuration, residual heat from refinery process streams, product cooling, condensate, cooling-water circuits or other low-temperature sources is recovered and used directly where the temperature level is sufficient. If the available residual heat temperature is too low, a heat pump can upgrade the heat to the tank-heating temperature level.

The measure can be implemented as a direct residual-heat loop, a heat-pump-assisted warm-water loop or a hybrid configuration in which the existing steam heating remains available for peak demand, start-up and fallback operation. The most important design parameters are required tank temperature, heat losses from tanks and piping, oil viscosity, pumping temperature, minimum approach temperatures, storage pattern, insulation condition and the distance between heat sources and tanks. A site-specific heat-source and heat-sink assessment is required to determine whether the residual heat can be used continuously and whether the heat-pump operating hours are sufficient for an attractive business case.



Measure 3: Tank heating with residual heat / heat pump

Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-3,703 MWh/a	-14.8%	
Change in electricity	+1,035 MWh/a	+23.5%	
Total change in energy	-2,668 MWh/a	11% of the reference plant	

CO₂ emissions scope 1

The change in natural gas is based on a reduction in steam or heat demand. Additional electricity must be incorporated into the site-specific business case and grid impact analysis.

CAPEX	Indicative	Remark
Main equipment	150 kEUR	100 kEUR heat pump water water and 50 kEUR of heat coils
Installation / Lang factor	6	
Total CAPEX estimate	900 kEUR	

Factors for implementation

Congestion

The measure can increase electrical demand when a heat pump is used for tank heating. The additional load is usually moderate compared with large steam-generating heat pumps or e-boilers, but available connection capacity, MCC capacity, transformer loading and cable routes must still be checked. If direct residual heat can be used without a heat pump, the grid impact is limited to circulation pumps, controls and auxiliary equipment. Hybrid operation with the existing steam system is recommended to manage grid limitations, maintenance, cold start-up and periods with unfavourable electricity prices.

Retrofitting

Brownfield implementation requires integration with existing tank coils, external tank-heating circuits, pipe tracing, steam traps, condensate return, control valves and temperature control systems. Additional scope may include heat exchangers, a heat-pump skid, warm-water or glycol loops, circulation pumps, insulation improvements, instrumentation and tie-ins to the tank farm. Space availability, accessibility around tanks, ATEX zoning, piping distances, heat losses and downtime requirements must be assessed. The existing steam heating should normally remain available as backup and for exceptional cold-weather or product-change situations.

Sustainability and other emissions

Water emissions are not expected to change significantly, because the measure mainly changes the utility system for tank heating and does not affect the refining chemistry. If a closed warm-water or glycol loop is introduced, leak prevention, maintenance and water-treatment requirements should be included in the site procedures.

Measure 3: Tank heating with residual heat / heat pump

Air emissions decrease because less LP steam or natural gas is required for tank heating and tracing. This reduces Scope 1 CO₂ emissions and NO_x emissions from the gas-fired boiler. The net CO₂ benefit must also include any additional electricity consumption from the heat pump and circulation pumps. The final emission reduction should be calculated with site-specific boiler efficiency, fuel emission factors, heat-pump COP and electricity emission factors.

Technical maturity

The individual technologies are mature: heat exchangers, tank-heating circuits, warm-water loops, circulation pumps and industrial heat pumps are commercially available. The main uncertainty is the process integration and the continuous match between residual-heat availability and tank-heating demand. Technical validation should focus on required tank temperatures, heat-loss calculations, tank and piping insulation quality, oil viscosity, heat-source profile, heat-pump COP, hygiene and product-quality requirements, ATEX zoning and operational flexibility. The measure is therefore suitable for feasibility screening and can be developed further with site-specific tank-farm data and vendor input.

Possible suppliers

Potential suppliers include heat exchanger, tank-heating and industrial heat-pump suppliers such as Alfa Laval, GEA, SPX Flow, Kelvion, API Heat Transfer, HRS Heat Exchangers, Spirax Sarco, Armstrong International, Johnson Controls/Sabroe, Everllence, Atlas Copco, Howden/Chart and other specialised heat-recovery and high-temperature heat-pump vendors. Final supplier selection should be based on tank-heating temperature, oil properties, food-grade requirements, heat-source availability, ATEX requirements, cleanability, service support and integration with the existing steam and condensate system.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x due to reduction of natural gas demand	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors of heat pump. Can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	None	Low

The permit implications of this measure are expected to be low. The main consideration is the working medium in the heat pump. Please refer to legislation about allowable quantities for ammonia and hydrocarbons. Noise generation from the heat pump compressor might require acoustic measures. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment and compressor noise. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

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Subsidy screening

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Subsidy	Match	Comment
DEI+	Most likely no match	Proven technology therefore likely not subsidised under DEI+
VEKI	Highly likely match	Could fall under Energy efficiency (art. 38). Heat exchangers and industrial heat pumps are mature, commercially available technology, supporting the proven-technology requirement, though at least three comparable reference projects for this specific application would need confirming.
EIA	Possible match	If a heat pump is used, code 221103 [W] "Warmtepomp" could apply, requiring a halogen-free refrigerant and a minimum COP set by the temperature lift between heat source and delivery. The permit section points toward ammonia or hydrocarbon refrigerants, both halogen-free, but the minimum COP needs to be met too.
SDE++	Possible match	Closed heat pumps are within the SDE-scheme. Minimum COP 2.3. only halogen-free refrigerants

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Unlikely	

The financing requirement is too low to warrant external financing.

Refining

Measure 4: Heat pump to produce LP steam for utilities

Summary

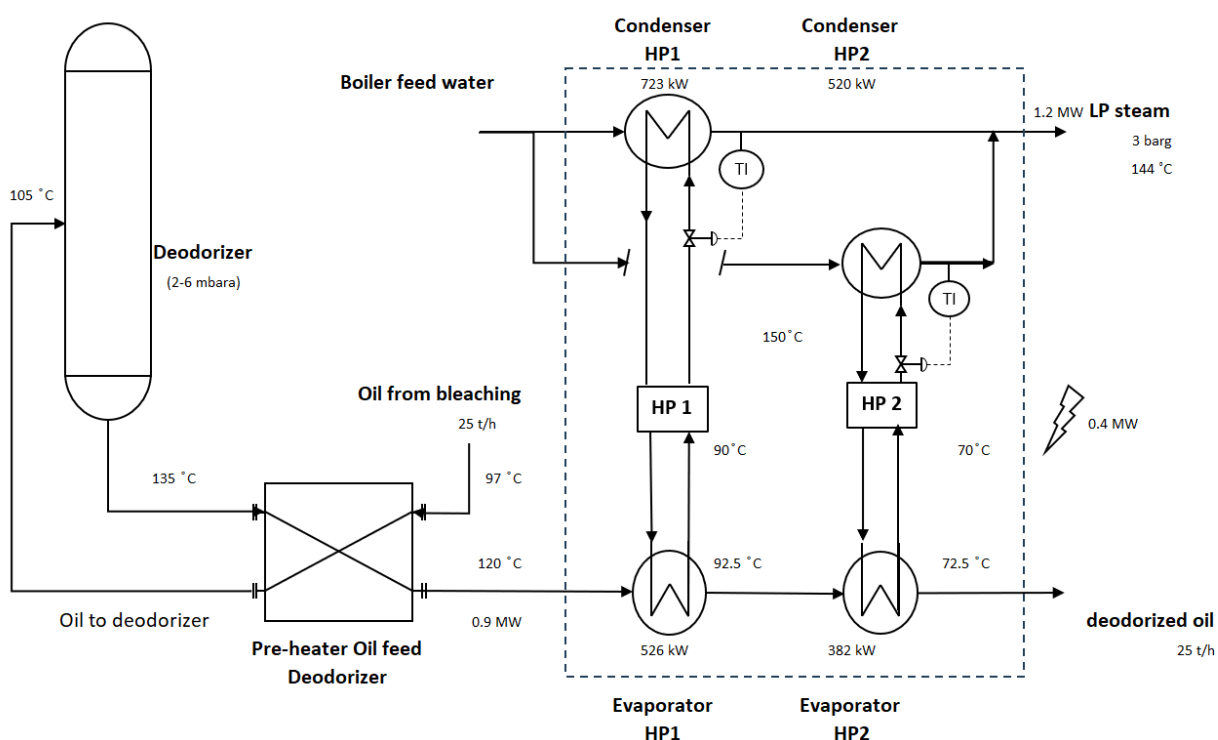
This measure uses a high-temperature heat pump, steam-generating heat pump or MVR-type concept to upgrade available residual heat into LP steam or an equivalent low-pressure heat carrier. The upgraded heat can partly replace boiler-generated LP steam for suitable refinery users such as tank heating, tracing, low-temperature oil heating and stripping or sparging. The measure can reduce natural gas consumption in the steam system and lower direct CO₂ and NO_x emissions, but it also increases electricity demand. Practical feasibility depends on a stable match between residual-heat availability and LP-steam demand, the required temperature lift, heat-pump performance, electricity and gas price balance, available grid capacity, retrofit complexity and the operating strategy of the existing steam system. Because several Refining measures may rely on the same residual heat sources or reduce the same steam demand, this option should be assessed together with the wider site heat and steam balance.



Technical description

In the existing situation, LP steam is generated centrally in a gas-fired boiler and distributed to several refinery users. At the same time, the refinery rejects low- and medium-temperature residual heat, for example from product cooling, condensate, warm process streams or cooling-water circuits. The proposed measure captures a suitable residual-heat source and upgrades it with a heat pump or vapour recompression system to produce LP steam or a steam-equivalent heat carrier. This LP steam can then partially replace boiler-generated steam for suitable low-pressure users.

The key design question is whether the site has a stable match between heat source and LP-steam demand for sufficient operating hours. The measure performs best when residual heat is continuously available and the LP-steam sink can absorb the upgraded heat without frequent venting, bypassing or boiler turndown limitations. Final design should therefore include a heat-source and heat-sink assessment, steam-balance review, condensate integration, control philosophy, fallback operation with the existing boiler and an economic evaluation based on electricity-to-gas price ratio and expected COP.



Measure 4: Heat pump to produce LP steam for utilities

Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-1.401 MW	-56%	-10,311 MWh/a
Change in electricity	+0.456 MW	+91%	+3,649 MWh/a
Total change in energy	-0.945 MW	28% of the reference plant under the assumption all waste heat can be used for 8,000 h/y.	-6,661 MWh/a
CO ₂ emissions Scope 1			-2,268 ton/a

CAPEX	Indicative	Remark
Main equipment	2 × 2 MW water–steam HP, 1,500 kEUR	Compressors, reboilers, heat exchangers, pumps, controls and/or vendor package
Installation / Lang factor	~5	Brownfield factor, ATEX, tie-ins, civil/steel, E&I and downtime
Total CAPEX estimate	7,500 kEUR	Indicative screening only

Factors for implementation

Congestion

The measure creates a significant additional electrical load because compressor power is required to upgrade residual heat to LP steam. The grid impact can be substantial, especially if several MW of LP steam is produced. Available connection capacity, transformer loading, MCC or medium-voltage infrastructure, cable routes and power-quality requirements must therefore be checked early. Hybrid operation with the existing steam boiler is recommended to manage grid limitations, maintenance periods, peak steam demand and periods with unfavourable electricity prices.

Retrofitting

Brownfield implementation requires integration with both the residual-heat source and the LP-steam system. Typical scope includes heat exchangers or evaporators, heat-pump or MVR compressor package, circulation pumps, condensate handling, steam separators, controls, safety systems and tie-ins to the LP-steam header. Space availability, lifting routes, noise, vibration, ATEX zoning, pressure-equipment requirements and downtime windows must be checked. The existing boiler should normally remain available for backup, start-up and peak operation.

Sustainability and other emissions

Water emissions are not expected to increase significantly. The measure mainly changes the way LP steam is generated rather than the process chemistry. Depending on the selected concept, additional condensate handling, blowdown, water treatment or closed-loop heat-transfer media may be introduced. These streams should be connected to the existing water and wastewater management procedures.

Air emissions decrease because less boiler-generated LP steam is required. This lowers natural gas consumption and therefore reduces Scope 1 CO₂ and NO_x emissions. The NO_x reduction should be calculated from the avoided boiler load and the site-specific boiler emission factor.

Technical maturity

Industrial heat pumps and MVR systems for hot water, low-pressure steam and process-heat applications are commercially available, but steam-generating heat pumps remain more site-specific than conventional heat exchangers or standard utility equipment. The technology maturity is sufficient for feasibility development, provided the temperature lift and operating conditions are within vendor experience. Key validation topics are residual-heat temperature and availability, LP-steam pressure, COP, compressor type, refrigerant or working medium, steam quality, turndown, redundancy, maintenance concept and integration with the existing steam balance.

Possible suppliers

Potential suppliers include industrial heat-pump, MVR and steam-generation technology suppliers such as GEA Heating & Refrigeration, Johnson Controls/Sabroe, Everllence, Atlas Copco, Howden/Chart, Mayekawa, SPX Flow, Kobelco, Oilon, Siemens Energy and other specialised high-temperature heat-pump vendors. Final supplier selection should be based on LP-steam pressure capability, achievable temperature lift, COP, working medium, references in food or process industries, ATEX and safety requirements, service support and integration with the existing steam system.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x due to reduction of natural gas demand	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors of heat pump. Can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	The refrigerant type and quantity determine the permit implications	Low to medium; ATEX and HAZOP review required
External safety	None	Low

The permit implications of this measure are expected to be low. The main consideration is the working medium in the heat pump. Please refer to legislation about allowable quantities for ammonia and hydrocarbons. Noise generation from the heat pump compressor might require acoustic measures. The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment and compressor noise. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

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Subsidy screening

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Measure 4: Heat pump to produce LP steam for utilities

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes](#). B. Relevant RVO subsid

Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38). It is described here that steam-generating heat pumps are "more site-specific" than standard heat pump or heat-exchanger equipment, so technical risk is more present here. Whether this exact configuration already exists in the Netherlands isn't established.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). The underlying heat-pump/MVR technology is described as commercially available, but it is noted that steam-generating heat pumps specifically are more site-specific than standard equipment, so confirming three comparable reference projects of this particular steam-generating setup, not heat pumps in general, would be necessary.
EIA	Possible match	This measure names three possible routes (high-temperature heat pump, steam-generating heat pump, or MVR), which point to different codes. An MVR-type system could fall under code 270102 [W] "Stoomrecompressie". A refrigerant-based heat pump could fall under code 221103 [W] "Warmtepomp," requiring a halogen-free refrigerant and a COP matching the temperature lift.
SDE++	Likely match	MVR's are within the SDE-scheme, depending on COP and process-changes.

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Likely	Operational lease
External ownership & operation (ESCO)	Likely	

This installation is implemented as a standalone unit or utility. Financing of project costs by an ESCO is likely, depending on the scope allowed by the client, and/or the level of possible collaboration. The measure is based on a relatively standard utility concept in which residual heat is upgraded to LP steam for multiple users, making it well aligned with heat-as-a-service and utility outsourcing models.

The installation can easily be removed as a standalone unit without significant consequences for the building or the production line. While the heat pump, steam-generating heat pump or MVR package is connected to the residual-heat source and LP-steam distribution system, the installation remains largely independent from the core refining process. Individual components such as the compressor package, heat exchangers, pumps, steam separators and auxiliary equipment retain residual value and can generally be recovered and redeployed in other industrial heat-recovery applications. However, removal would require modifications to utility piping, heat-source connections, controls and instrumentation. Consequently, the solution is likely to be suitable for operational lease financing.

Refining

Measure 5: Dry vacuum pumps instead of steam ejectors

Summary

This measure replaces steam ejectors used for refinery vacuum services with dry mechanical vacuum pump technology, where technically suitable. In oil refining, steam ejectors are commonly applied for deep vacuum duties such as deodorisation and, in some cases, vacuum drying. Replacing motive steam with electrically driven dry vacuum pumps can reduce steam demand, boiler fuel use, cooling load and condensate generation. The measure increases electricity consumption and must therefore be assessed against grid capacity, electricity price, required vacuum level, vapour composition, fouling risk and product-quality requirements.



Technical description

The existing configuration typically uses multi-stage steam ejectors, often combined with inter-condensers and after-condensers, to maintain the required vacuum in deodorisation or other refinery vacuum duties. The ejectors consume motive steam continuously and create a cooling and condensate load. In the proposed configuration, part or all of the steam-ejector duty is replaced by a dry screw or claw-type vacuum pump package, potentially combined with surface condensers, cold traps or booster stages depending on the required pressure level. For deodorisation, the required vacuum can be in the deep-vacuum range, so the final pump train may still require a hybrid configuration with pre-condensation, booster equipment or a retained ejector stage for peak or start-up conditions.

The main energy benefit is the avoided motive steam demand. This reduces natural gas consumption in the boiler system and can also reduce cooling water demand because less steam is condensed in the vacuum system. The countereffect is additional electricity demand for the mechanical vacuum pumps and auxiliaries. The final saving therefore depends on the existing steam ejector steam rate, condenser performance, air leakage, vapour load, operating hours, achievable vacuum level, maintenance condition and whether the existing ejector system can be fully removed or must remain as backup. A site-specific vendor assessment is required to confirm the achievable vacuum, pump materials, sealing concept, cleanability, ATEX classification and expected maintenance requirements.

Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-0.328	-12%	-2,624 MWh/a
Change in electricity	+0.062 MW	+11%	+493 MWh/a
Total change in energy	-0.266 MW	8% under assumption motive steam equals net oil heating.	-2,131 MWh/a

CO₂ emissions Scope 1

-532 ton/a

The change in natural gas is based on a reduction in steam or heat demand.

CAPEX	Indicative	Remark
Main equipment	180 kEUR.	3 times 20 kw
Installation / Lang factor	~3	
Total CAPEX estimate	540 kEUR	

Factors for implementation

Congestion

The measure increases electrical demand because the vacuum duty is transferred from steam ejectors to electrically driven dry vacuum pumps and auxiliaries. The additional load is usually lower than large heat-pump or e-boiler measures, but available MCC capacity, transformer loading, cable routes and emergency-power philosophy must still be checked.

Retrofitting

Brownfield implementation requires integration with the existing vacuum header, deodorizer or dryer connection, condensers, cooling system, condensate handling, control system and safety instrumentation. Space near the existing vacuum skid, access for maintenance, noise control and vibration isolation should be checked. Product carry-over, fatty acid vapours, fouling and cleaning requirements are important design points. A phased or hybrid retrofit is preferred, where the existing ejector system remains available during commissioning and as fallback until stable operation of the dry vacuum system is demonstrated.

Sustainability and other emissions

The measure will reduce condensate and cooling-water load because less motive steam is condensed in the vacuum system. If additional condensers, cold traps or seal systems are installed, their drains and cleaning streams should be integrated into the existing wastewater and maintenance procedures.

Air emissions decrease because boiler steam production is reduced. This lowers Scope 1 CO₂ emissions and reduces NO_x emissions from the gas-fired boiler. The indicative NO_x reduction should be calculated from the avoided fuel use and the site-specific boiler emission factor. The net CO₂ benefit must also include the additional electricity consumption of the dry vacuum pumps.

Technical maturity

Dry screw and claw vacuum pumps are commercially available and widely used in industrial vacuum applications. For edible-oil refining, the technology is mature, but the application must be carefully engineered because deodorisation can require very deep vacuum and may involve fatty acid vapours, steam, odorous components and potential fouling. The measure is therefore suitable for screening and feasibility development, but not as a generic one-to-one replacement without vendor validation. Key validation topics are actual vacuum level, non-condensable load, vapour composition, condensation strategy, pump protection, materials of construction, cleaning concept, ATEX zoning and availability requirements.

Possible suppliers

Potential suppliers include vacuum pump and edible-oil process suppliers such as Busch Vacuum Solutions, Pfeiffer Vacuum, Atlas Copco/Edwards, Leybold, Becker, Flowserve SIHI, Graham Corporation, GEA and Alfa Laval. Final supplier selection should be based on achievable vacuum level, experience with edible-oil deodorisation or comparable vapour loads, materials of construction, ATEX requirements, cleanability, service support and integration with existing condensers and controls.

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x due to reduction of natural gas demand	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors of vacuum pump. Can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	Working medium in vacuum pump.	Low to medium; ATEX and HAZOP review required
External safety	No change	Low

The permit implications of this measure are expected to be low. The main consideration is the working medium in the vacuum pump. Please refer to legislation about allowable quantities for ammonia and hydrocarbons. Noise generation from the vacuum pump compressor might require acoustic measures.

The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment and compressor noise. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

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Subsidy screening

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Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38), match depends on novelty and risk of the application.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). Dry vacuum pumps are described as commercially available and widely used industrially, supporting the proven-technology requirement, though the specific application may narrow the pool of directly comparable reference projects.
EIA	Possible match	No specific Energielijst code present for vacuum pumps replacing steam ejectors. The generic energy saving code is 320000, but this requires a net savings ratio of at least 0.4 Nm ³ gas-equivalent per euro invested per year.
SDE++	No match	

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Unlikely	

The financing requirement is too low to warrant external financing.

Refining

Measure 6: Chilled condensing to reduce motive steam consumption

Summary

This measure reduces motive steam consumption in the deodorizer vacuum system by applying chilled condensing before or within the vacuum system. In the existing process, vacuum for deodorisation is generated by steam ejectors using MP motive steam and barometric condensing. Vapours are condensed with cooling water of approximately 25°C to 30°C. In the new process, vapours are condensed with chilled water of approximately 5°C to 10°C. This condenses more vapour before it reaches the ejectors, reducing ejector duty and saving motive steam.



Measure 6: Chilled condensing to reduce motive steam consumption

Technical description

In the existing process, the deodorizer vacuum system is generated by steam ejectors using MP motive steam and barometric condensing. Vapours from the deodorizer are condensed with cooling water, typically at approximately 25°C to 30°C. At this temperature level, part of the vapour load remains for the steam ejectors, which results in continuous motive steam consumption and associated cooling and condensate loads.

In the proposed process, chilled condensing is added to significantly reduce the deodorizer vacuum duty. Vapours are condensed with chilled water at approximately 5°C to 10°C instead of conventional cooling water. The lower condensing temperature increases vapour condensation upstream of the ejectors, reducing the remaining vapour load and therefore the required motive steam. The main energy benefit is the reduction in MP motive steam demand. The countereffect is additional electricity demand for chilled-water generation and circulation. Final feasibility depends on vapour composition, condenser design, chilled-water temperature, fouling and cleaning requirements, refrigeration efficiency, operating hours and integration with the existing ejector and barometric condenser system.

Key numbers

Energy consumption	Indicative	Relative	Annual / note
Change in natural gas	-0.606	-22%	-4,457 MWh/a
Change in electricity	+0.119 MW	+20%	+948 MWh/a
Total change in energy	-0.487 MW	15% under assumption motive steam equals net oil heating.	3,509- MWh/a
CO ₂ emissions Scope 1			-980 ton/a

The change in natural gas is based on a reduction in steam or heat demand.

CAPEX	Indicative	Remark
Main equipment	2x125 kEUR.	1x heat pump (water-water) incl HFO+ heat coils, buffer vessel
Installation / Lang factor	~6	
Total CAPEX estimate	1,500 kEUR	

Factors for implementation

Congestion

The measure increases electrical demand because the vacuum duty is transferred from steam ejectors to electrically driven dry vacuum pumps and auxiliaries. The additional load is usually lower than large heat-pump or e-boiler measures, but available MCC capacity, transformer loading, cable routes and emergency-power philosophy must still be checked.

Retrofitting

Brownfield implementation requires integration with the existing vacuum header, deodorizer or dryer connection, condensers, cooling system, condensate handling, control system and safety instrumentation. Space near the existing vacuum skid, access for maintenance, noise control and vibration isolation should be checked. Product carry-over, fatty acid vapours, fouling and cleaning requirements are important design points. A phased or hybrid retrofit is preferred, where the existing ejector system remains available during commissioning and as fallback until stable operation of the dry vacuum system is demonstrated.

Sustainability and other emissions

The measure will reduce condensate and cooling-water load because less motive steam is condensed in the vacuum system. If additional condensers, cold traps or seal systems are installed, their drains and cleaning streams should be integrated into the existing wastewater and maintenance procedures.

Air emissions decrease because boiler steam production is reduced. This lowers Scope 1 CO₂ emissions and reduces NO_x emissions from the gas-fired boiler. The indicative NO_x reduction should be calculated from the avoided fuel use and the site-specific boiler emission factor. The net CO₂ benefit must also include the additional electricity consumption of the dry vacuum pumps.

Technical maturity

Dry screw and claw vacuum pumps are commercially available and widely used in industrial vacuum applications. For edible-oil refining, the technology is mature, but the application must be carefully engineered because deodorisation can require very deep vacuum and may involve fatty acid vapours, steam, odorous components and potential fouling. The measure is therefore suitable for screening and feasibility development, but not as a generic one-to-one replacement without vendor validation. Key validation topics are actual vacuum level, non-condensable load, vapour composition, condensation strategy, pump protection, materials of construction, cleaning concept, ATEX zoning and availability requirements.

Possible suppliers

Potential suppliers include vacuum pump and edible-oil process suppliers such as Busch Vacuum Solutions, Pfeiffer Vacuum, Atlas Copco/Edwards, Leybold, Becker, Flowserve SIHI, Graham Corporation, GEA and Alfa Laval. Final supplier selection should be based on achievable vacuum level, experience with edible-oil deodorisation or comparable vapour loads, materials of construction, ATEX requirements, cleanability, service support and integration with existing condensers and controls.

Measure 6: Chilled condensing to reduce motive steam consumption

Permit screening

The table below indicates what effect this measure has on the environment and whether this could affect the general rules or the site-specific permit.

Environmental aspect	Change	Permit Implications
Emissions to water and soil	None	Not applicable
Emissions to air	Reduction of CO ₂ and NO _x due to reduction of natural gas demand	Positive impact; may require update of emissions overview
Energy consumption	Significant reduction	Positive impact; energy section of permit or EED documentation may require update
Noise	Compressors of vacuum pump. Can be placed in acoustic enclosure to minimize noise impact.	Medium; acoustic assessment may be required
Odor	None	Not applicable
Application of hazardous media	Potential due to refrigerant in cooling equipment	Low to medium; ATEX and HAZOP review required
External safety	No change	Low

The permit implications of this measure are expected to be low. The main consideration is the working medium in the vacuum pump. Please refer to legislation about allowable quantities for ammonia and hydrocarbons. Noise generation from the vacuum pump compressor might require acoustic measures.

The measure has a positive environmental effect through reduced natural gas consumption, CO₂ emissions and NO_x emissions, but introduces additional electrical equipment and compressor noise. A structured Management of Change, ATEX review, HAZOP and consultation with the competent authority are recommended before detailed engineering.

We advise you to check your specific situation using the online [Vergunningcheck - Omgevingsloket](#) and recommend that you discuss this with your regional [omgevingsdienst](#). For more information, see Appendix D. Relevant Permitting Guidelines.

Subsidy screening

The information below should be regarded as an initial point of reference. For advice tailored to your project and circumstances, **please consult RVO's subsidy webpages and have your project proposal reviewed by RVO ([project idee toetsen](#))**, which offers the opportunity to:

- discuss the feasibility of your idea and its likelihood of success;
- present your idea and receive feedback;
- identify any additional subsidies that may be relevant to you.

Taking these steps before work commences will improve your prospects of securing project funding. For further information, please refer to Appendix [B. Relevant RVO subsidy schemes..](#)

Subsidy	Match	Comment
DEI+	Possible match	Could fall under Energy efficiency (art. 38), match depends on novelty and risk of the application.
VEKI	Possible match	Could fall under Energy efficiency (art. 38). Chilled-water refrigeration is widely used industrially, supporting the proven-technology requirement, though the specific application may narrow the pool of directly comparable reference projects.
EIA	Possible match	A plausible code set exists (220212/220223/220225, energy-efficient cooling/freezing installations), all requiring a halogen-free refrigerant. Several of these carry capacity caps (subcritical systems under 100 kW; some 2026 sub-codes cap total site condensing capacity at 50 kW).
SDE++	No match	

Financing options

Model	Option	Notes
Balance sheet financing	Viable	
Lease	Unlikely	
External ownership & operation (ESCO)	Unlikely	

The financing requirement is too low to warrant external financing.

Refining

Watch List

Summary

The measures in this chapter were retained as watchlist or site-specific options. These measures may still be relevant for individual refinery sites but were not selected for detailed elaboration in the Top 5 because they have a lower generic applicability, stronger overlap with other selected measures, higher technical uncertainty, or insufficient standard-factory data for robust screening. They should be revisited during site-specific feasibility studies, especially when local process conditions, existing equipment configuration or available residual heat sources create a favourable application case.



M4 – Short-path or molecular distillation

Short-path or molecular distillation can reduce thermal stress and residence time during high-temperature separation by operating under very deep vacuum. The measure may be relevant for products that are sensitive to high temperatures or where specific quality requirements justify an alternative distillation route. For the standard Refining factory, the measure is kept on the watch list because applicability depends strongly on product portfolio, required separation duty, existing deodorizer design and product-quality constraints.

M6 – Water ring pumps or screw compressor for vacuum drying

This measure focuses on improving or replacing the vacuum system used for vacuum drying before bleaching. Alternatives such as water ring pumps, dry screw pumps or screw compressors may reduce steam or utility demand compared with less efficient vacuum generation concepts. The saving potential is expected to be more site-specific than for deodorizer vacuum systems, because the vacuum drying duty in the reference plant is smaller and strongly depends on moisture content, air leakage, operating pressure and existing pump configuration.

M7 – Absorption cooling with waste heat

Absorption cooling uses available residual heat to generate chilled water or cooling duty. In principle, this can reduce electrical cooling demand or support improved condensation in vacuum systems. The measure is kept on the watch list because its feasibility depends on the availability of a suitable heat source, a continuous cooling demand, achievable temperature levels and the site's existing cooling system. It may become attractive where waste heat is abundant and conventional cooling capacity is constrained.

M9 – Nano cavitation to reduce chemical use

Nano cavitation may improve mixing, reaction efficiency or impurity removal, potentially reducing chemical consumption in degumming or neutralisation. The measure could offer indirect sustainability benefits through lower caustic, acid or water use. It remains on the watch list because technical maturity and proof of performance for broad refinery application are less certain, and because the direct energy-saving effect is less clearly represented in the reference plant energy balance.

M12 – Use of residual heat or heat pumps in additional refinery duties

This is a broader site-specific measure covering remaining low-temperature heat users that are not fully captured by the selected tank-heating and oil-preheating measures. Examples may include additional product heating, utility loops, cleaning systems or smaller process heat duties. The measure is kept on the watch list because it overlaps with M2, M5 and M10 and requires a detailed site heat-source and heat-sink assessment to avoid double counting of savings.

Refining

Long list

Summary

The Refining longlist consists of twelve measures. These measures mainly target the thermal energy demand in storage, low-temperature oil heating, deodorisation, vacuum generation and utilities. The savings shown below are indicative screening values and are not additive without further process-integration analysis, because several measures use the same heat sources or reduce the same steam.



#	M	Measure	Process step	Indicative saving	Basis / remark
1	M1	Induction heating oil in deodorizer	Deodorizing / high-temperature heating	4%	Low priority because the business case depends on the efficiency and continued need of the HP steam system.
2	M3	Tank heating with residual heat / heat pump	Storage / utilities	15%	Relevant for crude-oil tanks and tracing, especially where oils require elevated storage temperatures.
3	M5	Dry vacuum pumps instead of steam ejectors	Vacuum systems / deodorizing	14%	Potentially relevant but requires validation of the existing steam ejector baseline and additional electricity demand.
4		Short-path / molecular distillation	Deodorizing / high-temperature heating	n/a	Mainly product-specific; not selected for the standard refinery case.
5	M4	Heat pump to produce LP steam	Utilities / heat pumps	34% GJ/a	Technically interesting where sufficient continuous waste heat is available, but business case and TRL should be checked carefully.
6		Water ring pumps / screw compressor for vacuum drying	Vacuum drying	n/a	Overlaps with M3 and depends on the vacuum-drying configuration.
7		Absorption cooling with waste heat	Utilities / cooling	n/a	Watch-list option; requires a matching cooling demand and sufficiently high-value waste heat.
8		Optimization of wash water and soap stock handling	Washing / neutralization	n/a	Indirect energy effect through reduced drying demand, water use and wastewater load.
9		Nano cavitation technology to reduce chemical use	Neutralization / washing	0 GJ/y	Sustainability and chemical-saving option rather than direct energy-saving option.
10	M2	Heat oil for degumming / neutralization with residual heat or heat pump	Degumming / neutralization	19%	Practical low- to medium-temperature heat electrification option, dependent on available waste heat.

11	M6	Deodorizer energy savings via improved vacuum system	Deodorizing / vacuum	31%	Strong option if the current deodorizer still uses steam-intensive vacuum or limited heat recovery. Supplier validation is required.
12		Use residual heat / heat pump in additional refinery duties	Utilities / residual heat	n/a	Broader site-specific heat-pump opportunity; insufficient data for standard-factory quantification.

Selection note

M11, M10 and M2 are the most robust Refining measures because they directly address energy users that are clearly present in the reference plant: deodorisation, low-temperature oil heating and tank heating. M5 has a high theoretical saving but should be treated carefully because it depends on the availability of sufficient waste heat and a useful LP-steam demand. M3 is retained in the top five because vacuum-system improvements can be highly relevant in older deodorizer systems, although the saving must be confirmed with site-specific data. M1 is not selected because the business case for induction heating is currently uncertain where HP steam remains available and required elsewhere. M4, M6, M7, M8, M9 and M12 remain watchlist or site-specific options. One measure (M11, Deodorizer energy savings via improved vacuum system) is not considered here in the top 5, as it is seen as a very logical step if the current deodorizer still uses steam-intensive vacuum or limited heat recovery. In this measure a very deep deodorizer vacuum is created by supplying low temperature cooling. Supplier validation is required.

The figure shows why the selected Refining measures focus mainly on the dominant heat users and utility systems in the reference plant. The largest relevant energy users are linked to deodorisation, high-temperature oil heating, tank heating and tracing, low- and medium-temperature oil preheating, and vacuum generation. Product cooling after deodorisation also represents an important heat-rejection stream, creating potential for residual-heat recovery, heat-pump integration and electrified heat upgrading.

Measure & Main Energy Mechanism

M1 - Electrification via induction heating of oil in deodorizer

M2 - Tank heating with residual heat

M3 - Dry vacuum pumps instead of steam ejectors

M4 - Lower HT heating by short-path / molecular distillation

M5 - Heat pump to produce LP steam

M6 - Water ring pumps / screw compressor for vacuum drying

M7 - Absorption cooling with waste heat

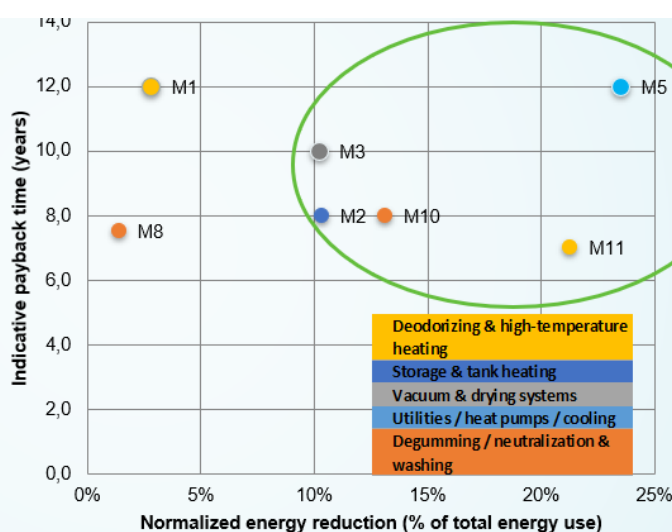
M8 - Optimization of wash water and soapstock handling

M9 - Nano cavitation technology to reduce chemical use

M10 - Heat oil for degumming / neutralization with residual heat or heat pump

M11 - Desmet deodorizer energy savings via improved vacuum system

M12 - Use residual heat / heat pump in additional refinery duties



The selected measures therefore target the main Refining energy users shown in the figure.

M1 focuses on replacing high-pressure steam generation for deodorizer heating with an e-boiler, where the relatively low efficiency of high-pressure gas-fired steam production creates an energy and CO₂ reduction opportunity. M10 addresses oil heating before degumming or neutralisation, while M2 targets LP steam demand for tank heating and tracing. M5 focuses on upgrading residual heat to useful LP steam, provided that a continuous heat source and matching LP-steam demand are available. M3 focuses on replacing steam ejectors with dry vacuum pumps where suitable, reducing motive steam demand and condenser load.

Measures outside this selection generally have a smaller contribution to the standard-factory energy balance, overlap with selected options, or are more site-specific, such as short-path or molecular distillation, vacuum-drying alternatives, absorption cooling, wash-water and soap stock optimisation, nano cavitation and additional residual-heat applications.

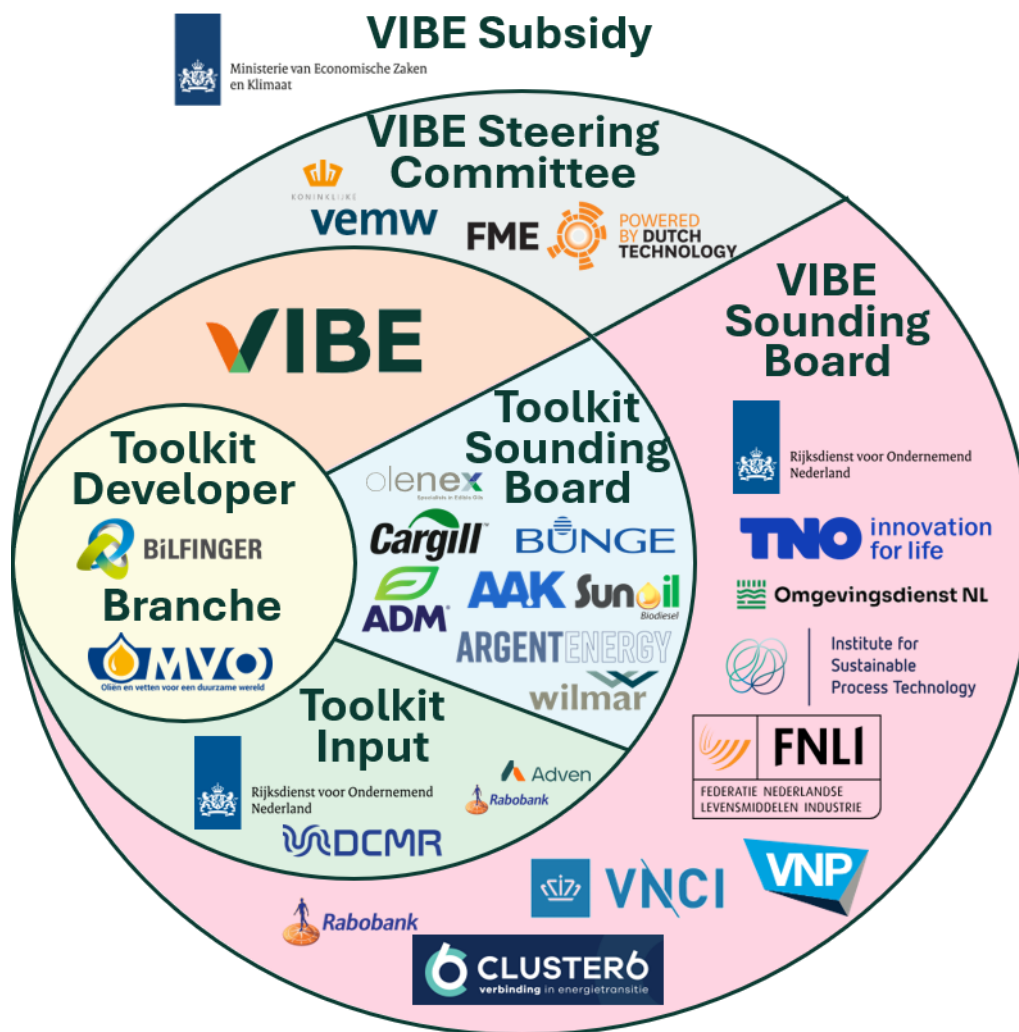


Appendices



A. Creation of this toolkit

The VIBE Toolkit was created through cooperation between many involved and committed parties



Trade association



MVO is committed to oils and fats in a sustainable world. MVO is partner in achieving a balance between People, Planet and Profit and represents 95% of companies in the Netherlands that are active in the production, processing and trade of vegetable and animal oils and fats. We represent the interests of the industry in contacts with the government, politics, social organisations, science and media.

Consultant



Engineering for greenfield plants or modification and modernisation projects for brownfield plants: We offer our clients the optimal solution in terms of efficiency and sustainability for process plants, oil and gas facilities, chemical and petrochemical facilities, energy transition, energy, industrial plant-related construction and infrastructure, and the pharmaceutical and biopharmaceutical industries—from feasibility studies and engineering to planning, consulting, and implementation. Thanks to decades of experience around the world, we can offer our clients a full range of engineering, design, and consulting services.

Following a public tender, Bilfinger was selected to develop this Toolkit. Their experience in the industry was decisive in this choice. This gave the development of the VIBE Toolkit a flying start. They have:

- Reference Plant Defined
- Energy analysis carried out
- Long list of solutions developed
- Top-5 selected and further developed
- The VIBE Navigator, Calculator and Catalogue compiled
- Periodically involved the sounding-board companies in the development process

Participating Toolkit sounding board companies



To ensure that the information is relevant to the industry, a validation process was periodically held with a select number of companies in the industry:

- Validating of the standard mills (extrusion, injection moulding and EPS)
- Validating the long list of possible energy-saving measures
- Assessment of the top 5
- Assessment of the Navigator (elaboration of the top-5)

VIBE Organisation



We help industrial companies save energy. We provide clear technical and financial information.

Our ambition is to enthuse a thousand of the largest companies in the industry from a realistic perspective and help them to achieve an average of up to 40% savings on energy consumption.

VEMW



VEMW VEMW is the leading knowledge center and advocate for business customers of electricity, gas, hydrogen, heat, and water in the Netherlands. For more than 100 years, we have been working with our members to ensure reliable, affordable, and future-proof energy and water supplies.

We represent companies and institutions and, by pooling knowledge and uniting interests, help shape national and European policy. With up-to-date information, expert advice, and a strong network, we assist our members with complex issues. Together with our members, we are committed to finding solutions for the energy and water transition that truly make a difference.

VEMW, together with FME, is the initiator of the VIBE initiative.

FME



The power of technology and collaboration

We are FME, the entrepreneurs' organisation for the technology industry. Together with our members, we create solutions that make the Netherlands and the world stronger: sustainable, innovative and for everyone. We connect, accelerate and defend, so that your ideas become reality – today and tomorrow.

FME, together with VEMW, is the initiator of the VIBE initiative.

Partners with active input in the VIBE Toolkits

RVO



We are RVO. We support, advise and encourage entrepreneurs in the Netherlands. We help entrepreneurs innovate and become more sustainable. Nationally and internationally, because our work does not stop at the border. We are facing major challenges in the world. It is time to make our economy, energy supplies, agriculture and food systems more sustainable. RVO is already working on tomorrow today.

RVO actively supports VIBE on various fronts and regularly sponsors the development of [technology best practices](#) in general.

RVO delivered the input on the subsidy screening and general subsidy knowledge.

DCMR

DCMR Milieudienst Rijnmond is the joint environmental service of the province of South Holland and thirteen municipalities in the Rijnmond region. DCMR is committed to a healthy, safe and sustainable living environment for the 1.3 million inhabitants of the Rijnmond region. We grant environmental permits to companies and check compliance with applicable environmental rules and other laws and regulations. In addition, DCMR advises governments on spatial plans with the aim of future-proof use of the physical living environment.

The consultancy branch of DCMR actively helps by indicating the permit consequences of VIBE Top-five measures.

Rabobank

Rabobank is an international, cooperative bank with Dutch roots. A bank without shareholders, but with members. A bank that's more about togetherness and less about going it alone.

Rabobank provided input for the financing options, especially for the lease opportunities.

Adven

Adven is a leading European energy group that develops, finances, and manages sustainable industrial energy and water solutions.

Adven provided input for the financing options, especially for the ESCO constructions.

Subsidy provider**Ministry of Economic Affairs and Climate Policy**

For an innovative and enterprising Netherlands!

- *Building a productive, resilient and sustainable economy*
- *Seizing opportunities for entrepreneurship and innovation*
- *Shaping climate policy and digitalisation*

VIBE Sounding board

The VIBE Sounding Board is the VIBE Team's source of advice, providing feedback from various perspectives. In addition, the sounding board actively contributes ideas regarding the VIBE initiative.

Participants in the Sounding Board are:

- **RVO:** Links the initiative to relevant (grant) programs and the National Platform for Sustainable Industry (NPVI).
- **TNO:** Serves as the link to knowledge and innovation and identifies new developments.
- **FNLI:** As a trade association, it serves as the link to 17 sectors and approximately 500 companies in the food industry.
- **VNP:** As a trade association, it serves as the link to 17 companies in the paper and cardboard industry.
- **VNCI:** As a trade association, it serves as the link to the chemical industry and represents approximately 380 companies (ranging from small startups to multinationals).
- **Rabobank:** Represents the commercial banks
- **ISPT:** The Institute for Sustainable Process Technology is a key partner that works closely with the industry, initiates projects, and connects organizations.
- **ODNL:** The Omgevingsdienst NL is the umbrella organization for Omgevingsdiensten
- **Cluster6:** Cluster6 represents regional industry in the Netherlands. As a networking and implementing organization, we support Cluster6 companies in their sustainability efforts

B. Relevant RVO subsidy schemes

This memo contains general information in general terms and is not advice on a concrete project or a commitment on eligibility. The applicable regulations – the subsidy schemes and manuals as published by RVO, the Energy List (EIA) and the underlying laws and regulations – form the actual basis; in the event of deviation, it always takes precedence over the content of this memo.

Regulations, budgets and conditions also change per opening round. Whether a project is eligible for a subsidy (VEKI, DEI+, SDE++) or energy investment deduction (EIA) can only be determined through an actual application or notification, and the assessment thereof by RVO.

For advice on your project and situation, visit the webpages about subsidies from RVO and have your [project idea tested at RVO](#):

- Discuss the feasibility of your idea and the chances of success together.
- Explain your idea and get feedback.
- You may discover other subsidies that are of interest to you.

Doing this before applying will increase your chances of getting a project grant.

To avoid the terms and conditions and information of the subsidy schemes being misrepresented or misinterpreted, this document does not address all the terms and conditions and refers to the correct pages where this information can be found. This is partly because these information pages are kept up-to-date. This prevents this document, or information presented in the VIBE toolkit, from becoming obsolete. In line with this, it is important to mention that the overviews below are based on information from 2026. Subsidy schemes are subject to change.

General guidelines:

- Before doing any preparatory work for a subsidy application, please check the relevant RVO website pages about the subsidies. There you will find additional information, manuals, calculation tools and useful links to support your preparations.
- **In various subsidy schemes, project ideas can be tested at RVO. By doing this before applying, you increase the chances of your project succeeding. More information about this can also be found on the website.**
- In various subsidy schemes, it is mandatory to perform certain calculations (e.g. payback time) with the calculation tool provided for the subsidy in question.
- RVO offers a wide range of subsidy schemes (WBSO, MOOI, EKKO, MIT,...) and even within the subsidy schemes below there is a distinction in categories. However, in this overview we only look at schemes and categories that may apply to VIBE measures.

STUDI: [Studies for Sustainable Industry](#)

- Nature of the project: finances a feasibility, environmental or similar study in preparation for a pilot or demonstration project, not the investment (CAPEX) of the technology itself.
- The follow-up project should lead to CO2 reduction in the Netherlands within 10 years of the study.
- The three study types are linked to a specific follow-up track:
 - A feasibility study prepares for a pilot project (e.g. a DEI+ pilot project);

- An environmental study prepares for a demonstration project or a project with mature technology (e.g. a DEI+ demonstration project or a VEKI project with mature technology);
- A similar study is for an environmental investment that does not fall under the AGVV.
- Payback time: no payback time requirement, this instrument funds the research phase, not the investment decision itself.
- Open application round with a fixed period, assessment in order of receipt until budget runs out.

DEI+: Demonstration Energy and Climate Innovations

- Nature of the project: pilot or demonstration project with an innovative/unproven technology, new to the Netherlands. For VIBE solutions, only demonstration projects will (most likely) apply:
 - Demonstration projects: you demonstrate the technology. The technology or its use is new to the Netherlands. And there are technical and economic risks, because it is not yet entirely certain whether the technology works well and is profitable.
 - VIBE solutions most likely fall under article 36 (other CO₂ reduction) or 38 (energy efficiency).
 - The project takes a maximum of four years; must lead to CO₂ reduction in the Netherlands within 10 years of its start.
- You start implementing your project within six months of receiving a letter from RVO approving your subsidy application (subsidy decision).
- You may not start your project, enter into any obligations or incur any costs before submitting your application (even if you do not yet pay these costs).
- Payback time: no payback time requirement — this instrument focuses on technical/economic risk of innovation, not on payback period.
- Open application round (fixed period), assessment in order of receipt until the budget runs out.

VEKI: Accelerated climate investments in industry

- Nature of the project: investment in proven (TRL 8–9) CO₂-saving technology in an existing industrial process.
- Payback time: intended for investments that have a payback time of more than 5 years without subsidy
 - For a payback time calculation for a VEKI application, use the calculation model at the bottom of the VEKI page.
- The subsidy can be limited by the "CO₂ price cap". This is calculated by €80/tonne x tonnes of CO₂ avoided over 15 years.
- You do not start work on your project before you submit the grant application. 'Start of work' includes:
 - Starting construction work for your investment;
 - Entering into orders without you being able to undo this;
 - Making other commitments that make your investment irreversible.
- Requires proven operation: at least 3 industrial reference projects in comparable service.
- Open application round (fixed period), assessment in order of receipt until the budget runs out.

EIA: [Energy Investment Allowance \(EIA\)](#)

- Nature of the project: investment in an asset that is on the Energy List with a specific code, or a generic asset that demonstrably meets a savings standard.
- Payback time: some codes have a payback time requirement; other codes do not.
 - Payback time calculation must follow EIA payback time calculation.
- Tax deduction, no direct subsidy payment.
- No proven operation requirement as with VEKI, but the asset must match a concrete [Energy List code](#).
- No application round: notification within 3 months of entering into the investment obligation, all year round.

SDE++: [Stimulation of sustainable energy production and climate transition \(SDE++\)](#)

- Nature of the project: production of renewable energy or low- CO₂ heat/production within a specifically defined SDE++ category (e.g. electric boiler, industrial heat pump or waste heat utilisation).
- Payback time: no payback time test — works via the unprofitable top (difference between cost price and market value of the energy/ CO₂ reduction).
- Operating subsidy, paid over 12–15 years per unit of product (kWh, tonnes of CO₂), not a one-off on the investment.
- Only relevant if the project falls within an existing category – not every energy saving is eligible, often with additional technical requirements (e.g. minimum power, efficiency requirements).
- One phased application round per year, ranking by subsidy intensity (€/ton CO₂).

NIKI: [National Investment Scheme for Climate Projects in Industry \(NIKI\) | RVO.nl](#)

The NIKI scheme is usually not suitable for VIBE measures, due to the minimum investment costs required (minimum requested subsidy amount of €30 million) to be eligible.

Accumulation and mutual effects of different subsidies

Combination	Quick scan treatment
STUDI & VEKI/DEI+/EIA/SDE++	Complementary, no competition: STUDI finances the study phase (before the investment decision), the other schemes finance the investment and operation themselves. Can therefore be used beforehand without stacking conflict.
VEKI & DEI+	Not as double support for the same costs. Choose the appropriate main scheme in terms of content.
VEKI/DEI+ & EIA	Easy to combine. Granted VEKI does reduce the EIA basis (rule of thumb: every €1 VEKI awarded results in €0.10 less EIA)
SDE++ & VEKI	Possible, but eventual SDE++ can be limited by state aid
SDE & EIA	Not possible
IF Heat Auction	The Heat Auction is a non-stackable scheme. See: Innovation Fund 2025 Heat Auction 19 February 2026

Opening calendar 2026

Scheme	Open	Close	Duration	Type
STUDI	May 18, 2026	March 31, 2027	Approx. 10.5 months	Open round (fixed period); in order from arrival to budget runs out
DEI+ (Energy and Climate Innovations)	January 27, 2026	July 30, 2026	6 months	Open round (fixed period); in order from arrival to budget runs out
VEKI	May 7, 2026	January 28, 2027	Approx. 8.5 months	Open round (fixed period); in order from arrival to budget runs out
EIA	All year round	All year round	Continuous	No application round; notification within 3 months of entering into the investment obligation
SDE++	October 27, 2026	26 november 2026	1 month	Phased on subsidy intensity (€/ton CO ₂); within each stage in order of entry

For VEKI, DEI+, SDE++ and STUDI, the application must be submitted before an irreversible commitment for the project (in the case of STUDI: the study) is entered into. An internal FID decision or preparatory engineering is not automatically fatal, but a binding equipment order, EPC contract or execution order (in the case of STUDI: an assignment to an external agency) can block the application. For EIA, the notification must be submitted within three months of each investment obligation; Reporting late can result in the loss of EIA entitlement for that obligation.

Overview of eligible costs and percentages 2026 for VIBE energy savings

Scheme	Eligible costs	Large company	Medium-sized company	Max. amount per project	Other limits
STUDI	Costs directly related to the execution of the study (own wage costs and costs for external parties.	Maximum 50% of eligible costs	Maximum 60% of eligible costs	Own wage costs capped at max. €25,000, regardless of the total study load; In larger studies, the bulk of the costs consist of costs for external parties (consultancy firms, laboratories, research institutions), not of own staff hours. Total €4 million	
DEI+	Project costs under art. 36 (other CO ₂ reduction) or art. 38 (energy efficiency); in demonstration specifically the additional costs compared to a counterfactual scenario. Additional costs compared to NO counterfactual scenario are also possible, but this halves the subsidy amount	30% (Art. 38) or 40% (Art. 36) of the overcharge (if not a counterfactual scenario, 15-20%)	40% (Art. 38) or 50% (Art. 36) of the overcharge (if not a counterfactual scenario, 20-25%)	Demonstration project: €30 million	
VEKI	Project costs under art. 36 (other CO ₂ reduction) or art. 38 (energy efficiency); Additional costs compared to a counterfactual scenario Additional costs compared to NO counterfactual scenario are also possible, but this halves the subsidy amount	30% (Art. 38) or 40% (Art. 36) of the overcharge (if not a counterfactual scenario, 15-20%) Minimum grant amount €125,000	40% (Art. 38) or 50% (Art. 36) of the overcharge (if not a counterfactual scenario, 20-25%) Minimum grant amount €30,000	€30 million (exceptions: €25 million for specific residual heat)	Max. €80 per ton of CO ₂ reduction over 15 years;

Scheme	Eligible costs	Large company	Medium-sized company	Max. amount per project	Other limits
EIA	Investment amount in business asset on the Energy List from €2,500 per business asset	40% extra deduction of the taxable profit (not a subsidy, but a tax scheme); Net tax benefit $\approx 40\% \times$ corporate income tax rate	Same as large company	€153 million investment amount per taxpayer (2026)	In the case of stacking with DEI+/VEKI, the subsidy received is deducted from the EIA basis before the 40% deduction; net tax benefit decreases by approximately €0.10 per €1 DEI+/VEKI subsidy received
SDE++	N/A (no percentage of investment costs; operating subsidy per unit of output)	(Basic amount – corrective amount) $\times$ realised production	Same as large company	No project maximum in €; limited by the subsidy ceiling of the round (€8 billion in 2026) and max. Eligible full-load hours per technique	Duration 12-15 years; basic amount is fixed, correction amount revised annually by PBL

Example calculations per subsidy

The information below provides an example calculation for each subsidy scheme. These example calculations give a general indication of how a subsidy amount is calculated. In reality, this can differ by technology, its implementation, the size of the company and the subsidy/scheme. The calculations below are based on the assumptions mentioned, which means that they can deviate from the grant amounts awarded in applications.

STUDI

In preparation for a demonstration project or an investment in a mature technology (e.g. a VEKI investment decision), with fictitious costs and for a medium-sized company:

Description	Calculation	Amount
Costs of external parties (consultancy firm/engineering firm)	—	€120.000
Own wage costs	Not eligible for an environmental study	€ 0
Total eligible costs	Only costs external parties	€120.000
Subsidy Rate	50% (basic) + 10% (medium-sized farm surcharge)	60%
Grant amount	€120.000 × 60%	€72.000

DEI+

An example of an investment in an innovative technique, with an investment amount of € 2,500,000:

Investment innovative energy saving project: € 2,500,000

Zero reference: conventional gas boiler: €800,000

With DEI+, a subsidy is usually not automatically calculated on the entire investment. The relevant basis is usually the **additional cost part compared to a realistic reference project**. For demonstration projects, depending on theme and company size, the subsidy percentages are roughly between 30% and 50% of the relevant additional costs. The subsidy rate depends on the category of aid. This includes the percentage for energy efficiency other than in buildings. These percentages apply to the DEI+ opening of 2026.

Example calculation

Post	Amount
Investment innovative project	€2,500,000
Gas boiler cost as a zero reference	– € 800,000
Additional costs for innovative project	€1,700,000

The theoretical subsidy is then calculated as follows:

$$\text{Subsidy} = \text{difference in cost} \times \text{subsidy percentage}$$

Situation	Percentage	Calculation	Indicative grant
Large companies, for example 30%	30%	€ 1.700.000 × 30%	€ 510.000
Medium-sized company, for example 40%	40%	€ 1.700.000 × 40%	€ 680.000
Small business, e.g. 50%	50%	€ 1,700,000 × 50%	€ 850.000

For example, for this demonstration project, the indicative grant could be **between €510,000 and €850,000**, depending on the precise DEI+ category, the size of the company and the eligible costs.

Important points of attention

The reference must make it plausible what you would actually invest without the innovative project. The reference installation must therefore be functionally comparable and appropriate to the situation, capacity and lifespan of the project.

In addition, it must be determined which costs are actually eligible. For example, costs for land, regular maintenance, financing, general operations and sometimes parts that are not directly attributable to the demonstration can be disregarded.

VEKI

To illustrate the VEKI subsidy calculation, based on the calculation logic from RVO's [budget model](#) applied to an investment that falls under art. 36 AGVV, for a medium-sized company, with a reference investment:

Description	Calculation	Amount
Investment costs	Total CAPEX	€2.500.000
Counterfactual investment	Reference investment (e.g. replacement of existing installation)	€ 800.000
Additional investment costs	Investment costs – Counterfactual investment	€1.700.000
Subsidy Rate	40% (basic art. 36) + 10% (medium-sized company)	50%
Maximum support	Additional investment costs × Grant percentage	€ 850.000
Support already received from other governments	—	€ 0
Maximum subsidy	Maximum support received – Support already received	€ 850.000

Effect of not applying a counterfactual scenario: if the applicant chooses not to use a counterfactual scenario, the entire investment (not just the additional costs, which are not present) will be used as the basis, at a percentage halved (in this example 25% instead of 50%). On the same investment (€2,500,000), this amounts to €625,000, in this case lower than with the counterfactual scenario, but that depends on the ratio between additional costs and total investment and can differ per project.

Please note, missing test CO₂ price cap. The RVO calculation model for the VEKI budget only calculates the subsidy on the basis of the percentage of the (additional) investment costs. It does not contain a test against the CO₂ price cap of a maximum of €80 per tonne of CO₂ reduction over 15 years, which is tested separately by RVO and can still limit the final subsidy, regardless of what this calculation model gives as a result. See here another indicative calculation with CO₂ price cap:

Description	Calculation	Amount
Intended CO ₂ savings	—	300 tons/year
Period of project	Fixed period from the scheme	15 years
Max. subsidie per ton CO ₂	Fixed ceiling VEKI	€80/ton
CO ₂ price cap	$300 \times 80 \times 15$	€360.000

Comparison with the percentage calculation from VEKI maximum subsidy calculation model

Type of amount	Amount
Outcome of maximum percentage calculation	€850.000
Outcome of the CO ₂ price cap	€360.000
Decisive (lower of the two)	€360.000

EIA

Description	Calculation	Amount
Taxable profit in 2026		€500.000
Corporate tax	First bracket up to €200.000: Above €200.000:	19% 25,8%
Investment in energy project		€300.000
EIA percentage		40%
EIA amount	40% of €300.000	€120.000
New taxable profit	€500.000 - €120.000	€380.000
Original corporate tax	19% x €200.000 + 25,8% x €300.000	€115.400
New corporate tax	19% x €200.000 + 25,8% x €180.000	€ 84.440
Tax benefit	€115.400 - €84.440	€ 30.960
Net EIA-benefit (% of investment costs)	€30.960 / €300.000	10.3%

SDE++

The subsidy awarded in the decision is the maximum amount over the entire duration of the subsidy. RVO determines this maximum with the specified capacity of your production installation and of the production. The production has an upper limit based on a maximum number of full-load hours per category.

What is the final amount of the subsidy that you will receive? RVO calculates this per year. It is always about the amount of energy you produce. Or about the amount of reduced CO₂ emissions. The amount of the proceeds also counts. These revenues depend on the market value of energy. This market value is determined annually by the Netherlands Environmental Assessment Agency (PBL).

Please note that the market value is a calculated average. This amount is therefore not focused on your own costs, revenues and concluded contracts.

You will also receive a subsidy up to a maximum number of full-load hours per year and the subsidy has a maximum duration. This term differs per category.

The formula to calculate the total grant amount is:

Maximum SDE++ contribution (basic amount or application amount – basic energy price or basic greenhouse gas amount) * the number of full-load hours * the capacity * the duration in years.

RVO publishes a webpage with information about calculations for the SDE++: [Calculation SDE++ | RVO.nl](#). At the bottom of this page you can also find calculation models. Please note: this calculation model is called 'SDE+' because it dates from before the expansion to SDE++ in 2020. The banking mechanism it shows (settling over/underproduction between years, max. 25%) is still part of the current SDE++, although the rules per category may have changed since publication of this file.

C. Relevant financing models

This appendix helps industrial companies determine, in broad terms, which financing structures are promising for energy-saving investments. The framework is intended for industrial sites subject to mandatory energy audits and for projects with an investment volume starting at a few million euros. The framework does not provide direct financial advice; the company's primary bank can help assess the current financial situation to arrive at a tailored approach. The following factors are relevant in this regard:

1. the financial context in which the company operates;
2. the significance of the investment for the company;
3. the nature of the investment;
4. the strength of the investment's economic performance.

The combination of these four factors determines which financing structures are the most logical, which are less obvious, and which are likely to be ruled out.

Overview of financing structures

Four main models are distinguished in this context.

Model	Financier	Ownership	Balance sheet	Customer purchases
Balance sheet financing	Factory	Factory	On balance sheet	Asset
Lease*	Leasing party	Factory (financial lease) Leasing party (operational lease)	On balance sheet (financial lease) Off balance sheet (operational lease)	Asset (financial lease) and sells to leasing party (operational lease)
External ownership and operation (ESCO)	External party	External party	Off balance sheet (BOOT/EPC)	performance

*Sensitivity regarding the encumbrance of assets (security interests) plays a major role here.

In addition to financing, the approach to implementation is also a key decision. If sufficient resources and expertise are available, the company can carry out the implementation itself. It is also possible to collaborate with project developers and ESCOs. Subsidies may also be sought for the implementation. A company can apply for a subsidy itself if it owns the asset. If it does not own the asset, it is possible to apply for a project subsidy (such as the SDE++).

The company's financial and accounting context

The first step is to determine the financial environment in which investment decisions are made. Financing energy-saving measures via the balance sheet is not ruled out on technical grounds, but not all industrial companies view new investments in the same way.

Are you an independent family business or a medium-sized manufacturing company (SME)? Then it makes sense to evaluate investments based on your own balance sheet position. You focus primarily on available credit capacity, solvency, EBITDA, and your relationship with your primary bank. Ownership of production assets is often a key starting point, making balance sheet financing the standard route. If there is insufficient collateral for a bank loan, a guarantee scheme like the BMKB-Groen can offer a solution, and subordinated loans are available through regional energy funds.

Are you part of a larger Dutch industrial group? Then an investment is often evaluated at the corporate group level. Your site competes with other locations for the same investment budget. The question is not only whether the project is financially attractive, but also whether it ranks better than other investment opportunities within the group. Available financing capacity and investment budgets are often managed centrally.

Are you part of an international group? Then an investment is usually evaluated from a consolidated perspective. Even if the business case for your Dutch site is strong, the impact on the group's leverage, capital structure, and objectives can be decisive. Accounting rules, consolidation effects, and international financing guidelines often play a significant role in this process. Does your organisation have high leverage, limited borrowing capacity, or form part of a private equity portfolio? If so, minimizing additional balance sheet strain may be a key priority. In such cases, avoiding the tie-up of additional capital is often more important than owning the asset.

Is capital available, but only deployed when it represents the most efficient use of resources? Then capital efficiency, return on invested capital, and shareholder value take centre stage. The question is not so much whether an investment *can* be financed, but whether it represents the best use of available capital compared to other strategic options.

The outcome of this step determines the financial logic used to evaluate investments. This serves as the starting point for the subsequent steps in selecting an appropriate financing method.

Scale of the investment relative to the company

If the investment is modest relative to your EBITDA and available financing capacity, it can often be financed through existing credit facilities, making balance-sheet financing the logical choice.

If the investment represents a significant portion of EBITDA, or if separate credit or investment approval is required, it becomes worthwhile to compare different financing methods and examine ownership, risk allocation, and financing costs more closely.

If the investment is large relative to the financial scale of your company, the question arises not only of *how* to invest but also of *who* is best positioned to bear the investment. Leasing, external ownership models, and project structures then become more relevant, particularly when available financing capacity is limited.

The scale of the investment thus largely determines which financing options are realistic and attractive.

Nature of the investment

The third step focuses on the technical position of the installation within the production process. This step is detailed for each measure in the main text and largely determines which ownership and operational models are realistic.

The first category consists of production-critical installations. These are installations directly involved in the production of the final product, such as furnaces, reactors, drying systems, or other process equipment. These assets are often highly specific to the location and product, making it difficult to operate them as standalone infrastructure. Consequently, ownership and operational responsibility usually remain closely tied to the plant itself. Furthermore, production-critical installations are often deeply integrated into the production process. When they are physically connected to the factory and cannot easily be removed or relocated as standalone assets, there is a greater likelihood that they will be legally classified as part of the real estate or the production plant itself. Consequently, lease and asset financing arrangements are often more difficult to structure, as financiers have less assurance that the equipment can be repossessed as a standalone asset in the event of bankruptcy.

The second category consists of process-supporting energy investments. Examples include industrial heat pumps, thermal storage units, waste heat recovery systems, or steam recompression systems. These installations support the production process without being a direct part of the production step itself. Although often technically integrated, their performance and energy savings can be more clearly defined than those of production-critical assets. This creates greater scope for alternative ownership and operational models.

The third category comprises standalone utility systems. These include, for instance, steam plants, heating plants, cooling systems, water treatment facilities, compressed air systems, and battery storage systems. These installations provide a clearly defined service to the factory and generate a measurable output. As a result, they can be relatively easily decoupled from the primary production process and are often suitable for leasing, project financing, and third-party operation.

Economic performance of the project

Once the technically feasible financing options have been identified, the next step is to determine whether the project is economically robust enough to support these structures. Key factors here are the payback period and the predictability of future cash flows. A project characterized by stable operating hours, easily measurable performance, and predictable savings or revenues offers financiers greater certainty and opens possibilities for alternative financing and operational models. This applies particularly to ESCO and project finance structures. In such models, the investment is not primarily recouped from the company's general cash flows, but rather from a specific service, energy supply, or realized energy savings. The more effectively performance can be measured and contractually defined, the easier it becomes to transfer risks, ownership, operations, and financing to an external party.

Depending on how performance and risks can be defined, various types of contracts may be considered. Under an Energy Performance Contract (EPC), the investment is recouped from realized energy savings. An Energy Supply Contract (ESC) involves payment for supplied energy, such as heat, steam, or cooling. If an external party designs, finances, owns, and operates the installation, a Build-Own-Operate (Transfer)—or BOOT—structure may be used. These forms of external financing and operation become more attractive as cash flows become more predictable and performance easier to measure.

Interrelationship between the four steps

Together, the four steps form an integrated assessment framework. The first two steps outline the company's financial position and options, while the third and fourth steps describe the technical and economic characteristics of the investment itself. Only by combining these perspectives does a clear picture of the available financing capacity emerge. For instance, a financially robust group might be able to finance a major investment relatively easily yet still opt for an external operator because the installation can be technically decoupled from the production process without difficulty. Conversely, an independent company with limited financing capacity might be compelled to explore alternative structures, even though a highly integrated process installation is technically ill-suited for such an approach.

The final financing recommendation therefore does not stem from a single, isolated step, but rather from the interplay between the company's financial context, the scale of the investment, the technical nature of the asset, and the economic quality of the business case.

	Balance sheet financing	Lease	External ownership and operation (ESCO)
Commercial bank	Main role	X (via subsidiary)	X
Private debt/credit	Main role	X	X
Lease / asset finance	X	Main role	X
Energy fund	Sometimes	X	X
Project developer / ESCO	X	Sometimes	Main role

For amounts under €100k, financial lease is often an option, whereas for amounts over €500k, only operational lease is an option.

Given the complexity of the financial structures offered by ESCOs, projects only become attractive starting at €3 million, and ideally above €10 million.

InvestNL can play a role in capital investments with a ticket size > 10 million euros in combination with a commercial party like a bank with a similar investment.

D. Relevant Permitting Guidelines

Your company is going to become more sustainable. Before you get started, it's important to find out what legal obligations apply and what you need to take care of before making your changes. We recommend that you consult the [Permit Check - Environment Desk](#) and that you talk to your regional Omgevingsdienst at the planning stage.

With the you can investigate in advance whether you may need to apply for a permit or make a notification for your plans. The more complete you answer the questions, the better the Permit Check can indicate what you need to consider. You must ultimately submit the application or notification for change via the environmental desk. This applies to all notifications and permits (environment, construction and nature).

The [Omgevingsdienst](#) is a regional executive organisation of the competent authority such as the province and municipality. Based on the situation and the available information, the Omgevingsdienst determines which procedure must be followed and whether other authorities such as the Waterschap or the municipality should be involved.

Use the technical information from the VIBE Navigator to carry out the Permit Check and begin discussions with the Omgevingsdienst. By having the desired steps clear in advance, you prevent permits from influencing the critical path of your project.

In practice, with the Permit Check – Omgevingsdienst:

- 1. No permit required**

Some changes fit within the existing permit and/or fall entirely under the general rules. In that case, no permit or notification is required.

- 2. Obligation to report**

If no permit is required, general rules apply. For certain changes, a notification via the Permit Check - Omgevingsloket is sufficient. Check in advance which obligations apply and report the change at least one month in advance via the [Permit Check - Omgevingsloket](#).

- 3. Amendment of an existing permit**

Changes to an existing permitted environmental and construction situation must be notified via the [Permit Check - Omgevingsloket](#).

Regarding **the environment**, the consequences of change in relation to air emissions, noise, safety, storage of hazardous substances, waste flows, water use or production capacity must then be inventoried. The Omgevingsdienst determines which procedure is necessary for permit adjustment. Depending on the impact of change on the situation and the early submission of the correct information, the lead time for the permit procedure can vary from 2 to 9 months.

If the change is accompanied by **construction activities** such as the installation of foundations, pipe bridges or outdoor installation, a building application is often required. Changes within an existing building usually do not require a building application.

Finally, construction and construction work may require an assessment of effects on protected nature areas, including possible nitrogen effects. This assessment is project-specific.

E. Working with the VIBE Calculator

The VIBE Calculator is a simple spreadsheet tool for business-case calculations that allows you to:

- Adjust numbers **to your factory**
 - E.g. increase CAPEX because your factory capacity is larger than that of the reference plant.
 - You must, of course, then change the OPEX savings as well.
- Customize numbers **with better information**
 - E.g. adjust CAPEX because you have better information (e.g. key equipment quotes)
- Vary numbers **to better understand the impact on the business case**
 - E.g. subsidy of zero ("I am a pessimist") and maximum ("I am an optimist")
- Compare the **business cases of different measures**
 - E.g. measure #1 vs measure #4
- Compare **different energy scenarios**

Remark:

- A correction for the reference scenario is not included in the CAPEX subsidy calculation. The user has to adapt the CAPEX subsidy percentage himself for this purpose
- The subsidy calculations are an indicative calculation and do not replace in any way the official RVO calculations

The legend is:

Field colour	Description	Changeable
	Input	Yes
	Result	No
	Calculation	No
	Fixed / general parameter	No
	Suggested value	Yes

The default VIBE Calculator is protected so that fixed fields or formulas cannot accidentally be changed. However, if you want to expand the spreadsheet with other functionalities, the spreadsheet can be unlocked. This is of course entirely at your own risk.

If you have any questions about the use of the VIBE Calculator and/or have suggestions on how the VIBE Calculator can be improved, please do not hesitate to contact info@vibe2030.nl.

F. Practical examples: the VIBE Catalog

The VIBE Catalog lists existing projects that have already been implemented one or more of the top-five solutions (or for which at least a final investment decision has been made). The purpose of this reference list is:

- Demonstrate that the Top-five measures **have already been implemented somewhere**. Please note that sometimes an example comes from another industry, but the circumstances are very similar to those within the industry.
- Provide the opportunity to contact these companies (asset owner, OEM, installer,...) for more information

Call

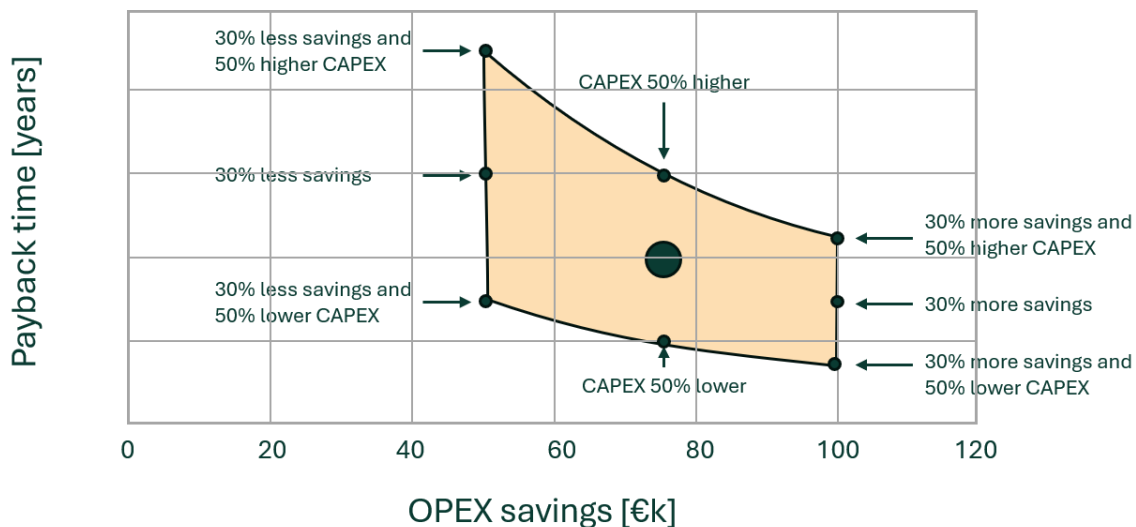
After determining the Top-five measures, there was relatively little time to compile these reference lists. In other words: this reference list is certainly not complete. If you:

- Want to add to existing references
- Want to provide new references

please contact the VIBE team, so that the reference list can continue to improve.

G. Accuracy of the key figures

Every factory is, of course, unique, with its own capacity, equipment with different ages, changes made in the meantime, sometimes unique feedstock and/or end products. The VIBE approach is to look at the energy-intensive steps within a reference plant with an 'average' capacity within the Dutch plastics processing industry. That is a simplification of reality. All numbers are therefore approximations that should be viewed broadly. In addition, no FEED was created and no quotations from suppliers were requested.



Suppose that a measure involves a CAPEX of €750k and OPEX savings of €75k and therefore with an estimated payback period of 10 years, then consider the following accuracy envelope:

The savings are more accurate than the CAPEX because the CAPEX is not only dependent on the layout and condition of the actual plant, but is also subject to geo-political tensions that fluctuate greatly