



BIO DIESEL EN 14214

The demand for biodiesel, as well as its various forms of application, is steadily increasing. Therefore, the selection of a suitable manufacturing and purification process is crucial. The following **white paper** explains how the biodiesel market is currently developing and which new technologies are available for biodiesel distillation.

WHITEPAPER - BIODIESEL DISTILLATION

Challenge: EN 14514

Until a few years ago, biodiesel production was almost exclusively based on fresh oils. Nowadays, the raw material base has changed significantly due to the increased use of fatty acids from residual and waste materials.

As a result, the demands on the purification process for the production of standard-compliant biodiesel have increased. Gentle distillation purification is necessary for the final step to achieve the desired quality.

Solution: Short-Path technology

The use of short-path technology ensures high-quality biodiesel production using a wide variety of raw materials while meeting individual customer requirements. In addition, the gentle rotation process guarantees that the required blending quality is obtained and enables above-standard ester contents.

With a FAME yield of up to 99%, the evaporator operates in a highly resource-efficient capacity. The necessary input for a customized solution is obtained through intensive trials and simulations in GIG Karasek's pilot plant.

Benefit: Everything from one source

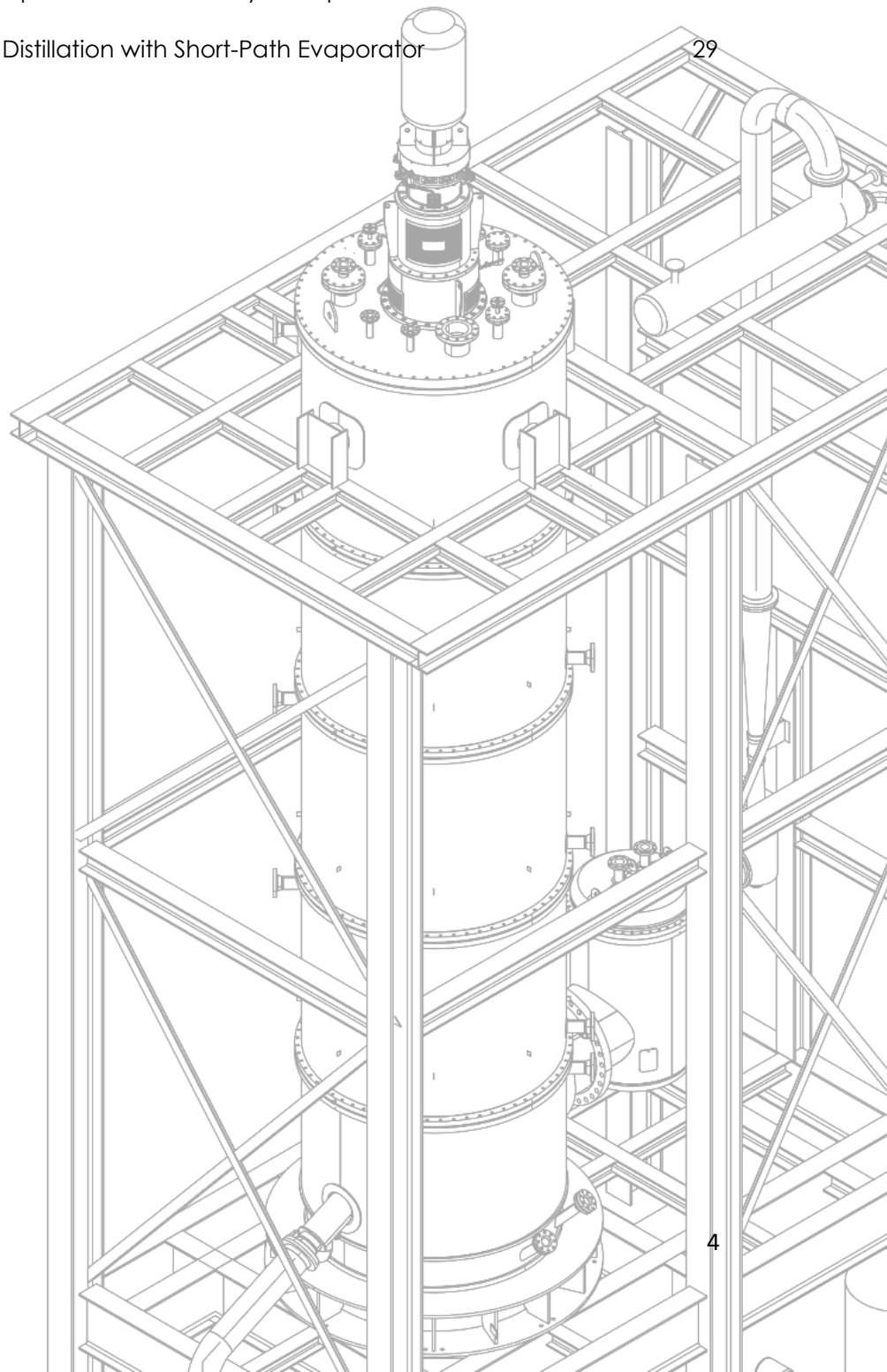
GIG Karasek has established itself as an expert in thermal separation technology over many years, especially in the distillation of thermally sensitive products. Our experts develop special problem-solving solutions for temperature-sensitive products such as biodiesel, that are precisely tailored to meet your requirements.

The main focus is on optimal energy utilization, resource efficiency, operational reliability, and easy-to-use equipment. Our team accompanies you through all production phases, from concept and pilot plant trials to manufacturing and final commissioning.

CONTENT

THE IMPORTANCE OF BIODIESEL IN THE CONTEXT OF A SUSTAINABLE ENERGY SUPPLY	5
Biodiesel as an important contribution to climate protection	5
Decarbonization increases biodiesel consumption	6
Comparison of FAME biodiesel and HVO biodiesel	6
The shortage of biodiesel plants causes prices to explode	8
First-generation biodiesel loses market opportunities	8
The paradigm shift in EU-Energy Policy	10
Biodiesel plants: Which plants are available on the market?	11
What is the status on the availability of sustainable raw materials?	12
Conclusion: The future lies in advanced biodiesell	13
BIODIESEL BLENDING QUALITY ACCORDING TO EN 14214	14
Inferior raw materials influence parameters	14
Guaranteed blending quality through distillation	14
THE SHORT-PATH DISTILLATION TECHNOLOGY	15
Gentle evaporation due to built-in condenser	15
Further advantages of the short-path evaporator are:	15
FAME yield of up to 99 % using short-path distillation	16
Conclusion: Biodiesel distillation from a single source	16
TECHNICAL CENTER: TEST INFRASTRUCTURE FOR SHORT-PATH EVAPORATORS	17
Distillation-Plant layout	17
Checking the blending quality of a feed	17
USE CASE & THE SCOPE OF SERVICES OF THE PLANT	18
Use Case: Optimization of a biodiesel plant according to EN 14214	18
THE THREE BIGGEST PROBLEMS IN BIODIESEL DISTILLATION	20
1. High sulfur content in biodiesel	20

2. Various composition and quality of raw materials	20
3. The higher complexity of biodiesel distillation plants	22
Conclusion: Individual solutions for biodiesel distillation	22
SHORT-PATH EVAPORATOR VERSUS RECTIFICATION COLUMN	23
Short-Path Distillation: One-Stage Process	23
Rectification: Multi-stage process	24
Advantages of the Short-Path technology	25
Investment costs: Short-Path evaporator considerably cheaper	29
Conclusion: Effective Biodiesel Distillation with Short-Path Evaporator	29



THE IMPORTANCE OF BIODIESEL IN THE CONTEXT OF A SUSTAINABLE ENERGY SUPPLY

The current climate discussion, high energy prices, and rising CO2 taxes have brought biodiesel back into the spotlight. Moreover, given the change in the direction of EU policy in the context of the "Fit for 55 Package", the production of advanced biodiesel, in particular, will be an essential topic for the coming years.

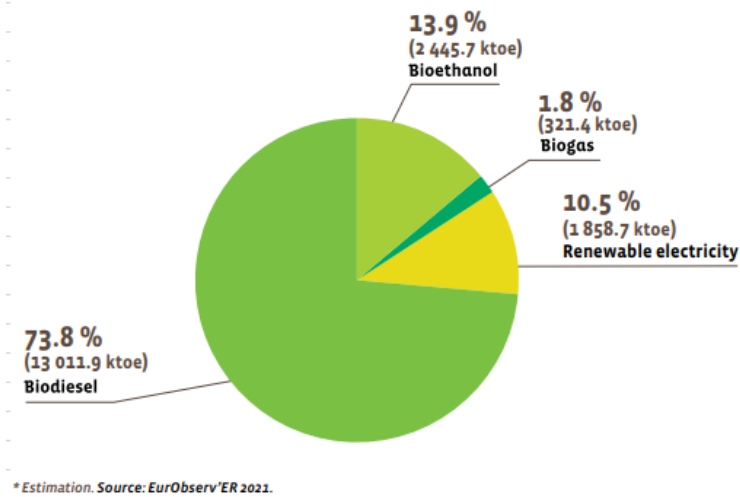
Over the past few years, the development of new processing technologies in this area has made considerable progress. The focus is on improving efficiency and recycling waste and residual materials generated as a result of cycle-optimized waste management

Biodiesel as an important contribution to climate protection

Biodiesel emits between 65 and 90 % less CO2 than fossil diesel and reduces CO2 emissions by around 3 kg with each kilogram of biodiesel. The use of biodiesel thus makes an important contribution to climate protection in the transportation sector.

In addition, the use of waste and residual materials contributes to a sustainable circular economy and transforms waste into a competitive and low-emission form of transport energy.

- Biodiesel accounts for the largest share of biofuel consumption in transportation. In 2020, this share was 73.8%.
- In total, biofuels were used in the EU at a rate of 15.8 million metric tons of which approximately 13 Mt were accounted for by biodiesel.



Road transport remains the most important sector for renewable energy consumption, ranking at almost 98%, ahead of rail and other modes of transport.

Decarbonization increases biodiesel consumption

With the decarbonization of the transport sector being pushed throughout Europe, biodiesel consumption is also on the rise. Companies that sell CO₂-emitting fuels must compensate for the greenhouse gas emissions generated when these fuels are burned. Those who violate the quota pay high penalties for each additional ton of greenhouse emitted gas.

The GHG quota for companies subject to quotas, mostly mineral oil companies, is to be gradually increased to 25% by 2030 (currently 6% in Austria). Accordingly, the demand for biodiesel is increasing.

Also in view of the insufficient expansion of production capacities for renewable electricity, biodiesel will take a leading role in replacing fossil fuels in the coming years in order to achieve the ambitious goals of climate change.

Comparison of FAME biodiesel and HVO biodiesel

Biodiesel can be used as a pure fuel or blend component in all modes of transport (road, air, sea and inland shipping transport). Road transport dominates in terms of volume, but there are opportunities for growth for other applications as part of the EU's [Fit for 55-Pakets](#).

- Both FAME biodiesel (fatty acid methyl ester) and HVO biodiesel (hydrogenated vegetable oil) are approved for blending with fossil diesel.
- Both are produced from renewable feedstocks, including vegetable oils, used cooking oils (UCOs), animal fats, and biogenic waste and residual materials

Although FAME and HVO use similar raw materials, the production processes and the properties of the biodiesel produced are different. This subsequently influences the blending options:

1. FAME-Biodiesel

FAME is produced by transesterification of fats or oils with methanol. The end product is similar to conventional diesel but has a higher oxygen content.

- FAME biodiesel is marketed as a pure fuel at service stations, but it is also blended with fossil diesel.
- The added biodiesel must meet the blending quality requirements of EN 14214

- When produced from waste and residual materials, final purification through distillation is required.

In Europe, a maximum of 7% FAME is permitted in diesel fuel (B7). To reduce global CO2 emissions, this proportion is to be increased in the future according to current EU plans. Pure FAME biodiesel (B100) may only be used for suitably designed engines.

2. HVO-Biodiesel

HVO is developed by hydrogenating vegetable oils and fatty waste materials instead of methanol. Compared to FAME biodiesel, HVO is a hydrocarbon almost chemically identical to mineral diesel.

- Since HVO biodiesel does not differ from fossil diesel, it can be used as a pure fuel without having to adjust the engine.
- Blending is possible in any mixing ratio as long as the diesel fuel standard DIN EN 590 is met.
- HVO is currently used as an additive in aviation.

BIODIESEL	FAME	HVO
Production	Transesterification with methanol + distillation	Hydrogenation with hydrogen
Raw materials	Vegetable oils, plant and meat fats	Plant-based oils and fatty residual and waste materials
Characteristics	Higher oxygen content than fossil diesel	Chemically identical to fossil diesel
Blending	A maximum of 7% standard biodiesel according to EN 14214	Unlimited mixing ratio, provided standard DIN EN 590 is fulfilled
Pure fuel	Only for appropriately designed engines	No adaptation of engines required

The shortage of biodiesel plants causes prices to explode

High raw material costs and the flooding of Europe with palm oil biodiesel at dumping prices have led to considerable price pressure in the European biodiesel market in recent years. As a result, numerous biodiesel plants in Europe have closed their doors.

In addition, price increases on the crude oil market and rising CO2 taxes exacerbate the market situation. Oil companies, which have to meet their GHG reduction obligations, are now desperate to find biodiesel blended with other fuels.

Given the increasing commitment to climate protection and more sustainable energy use, demand and price levels are likely to remain high in the future.



[NESTE](#)

First-generation biodiesel loses market opportunities

Among other things, biodiesel is regulated according to the type of feedstock used and is divided into different categories. The classification determines whether crediting is permitted in calculating the national share for renewable energies. In addition, a distinction is made between "conventional" and "advanced" biodiesel, also called first-generation and second- or third-generation biodiesel.

- **Conventional biodiesel:** First-generation biodiesel is produced based on raw materials that serve as food and animal feed. These include vegetable oils that can also be used as food.
- **Advanced biodiesel:** Second-generation advanced biodiesel uses animal and plant waste and residues that do not compete directly with food and feed crops. These include, for example, FAME biodiesel from used cooking oils or HVO biodiesel from tall oil. Third generation biodiesel is produced through microbial production and does not compete with food production. Microalgae, bacteria, fungi, and yeasts are used as raw materials. Intensive research is still underway in this area.

The [EU-ILUC](#) Directive introduced a 7% cap on the creditable contribution of first-generation biofuels (CAP 7) and a target benchmark for advanced biofuels. Accordingly, biodiesel derived from food and feed crops may not exceed 7% of final transport consumption.

Furthermore, if these food and feed crops entail a high risk of indirect land-use change, the value will be gradually reduced to 0% by 2030. In the future, therefore, more advanced biodiesel is to go into the tank.



Five years ago, the world's first bio refinery for the production of advanced HVO biofuels started commercial production in Lappeenranta, Finland. At its HVO plant, UPM Biofuels produces about 160 million liters of advanced biofuels and biomaterials annually based on tall oil. © UPM Biofuels

The paradigm shift in EU-Energy Policy

Europe has set a target to reduce greenhouse gas emissions by 55% by 2030 compared to 1990 levels. To achieve this goal, several updates to energy legislation are currently underway. At the core of these updates is the Renewable Energy Directive ([RED II](#)) amendment as part of the „[Fit for 55](#)“- package.

The directive revision promotes investments in existing or new renewable energy technologies. To reach this goal, the overall target for renewable energies is set to be increased from 32% to 40%. Furthermore, important changes are as follows:

1. Emissions-based benchmark in the transport sector

In the transport sector, the introduction of a GHG reduction target of 13% based on a new emissions-based benchmark is planned. The reduction target by 2030 corresponds to an energy-based target of 28% using the methodology in the current directive (RED II).

2. No double counts for charging purposes

An additional secondary target is provided for advanced biofuels at the rate of 2.2% by 2030. Biofuels produced from feedstocks listed in Annex IX-A and B of the Directive may no longer be dually counted when meeting national targets.

Therefore, the new regulation leads to a significant increase of requirements in the transport sector, compared to the current target of 14% for transport (energy-based) and a sub-target of 3.5% for advanced biofuels.

3. Promotion of advanced biofuels

About 30 years ago, Austria was a pioneer when the world's first biodiesel plant went into operation. At that time, biodiesel was still considered an unusual, environmentally friendly and renewable energy source. Today, the EU is a world leader in producing and using biodiesel. Almost 200 plants of different generations are in operation across the EU, producing around 13 million tons of biodiesel annually.

Biodiesel plants: Which plants are available on the market?

About 30 years ago, Austria was a pioneer when the world's first biodiesel plant went into operation. At that time, biodiesel was still considered an unusual, environmentally friendly and renewable energy source. Today, the EU is a world leader in producing and using biodiesel. Almost 200 plants of different generations are in operation across the EU, producing around 13 million tons of biodiesel annually.

Bio refineries 1. Generation: FAME biodiesel from pure vegetable oil

1st generation biodiesel plants can only utilize oilseeds. In 1989, the world's first commercial biodiesel plant was launched by the Gaskoks company in Austria. In the years that followed, investors in Europe built numerous other biodiesel plants, and by 1998, 21 European countries were implementing commercial biodiesel projects.

Bio refineries 2. Generation: FAME biodiesel from waste and residual materials

At the beginning of the 2000s, in the "tank or plate" discussion, new processes were developed to enable biodiesel production from the waste fraction of oil mills and other residual and waste materials. However, 2nd generation biodiesel must be distillatively enhanced in an additional process step to meet the requirements of the European Biodiesel Standard EN 14214. The short-path technology represents an optimal process for thermally sensitive biodiesel.

Bio refineries 3. Generation: HVO biodiesel from renewable raw materials

In recent years, hydrogenated vegetable oil has become increasingly important as a diesel substitute, spawning a new generation of biodiesel plants.



What is the status on the availability of sustainable raw materials?

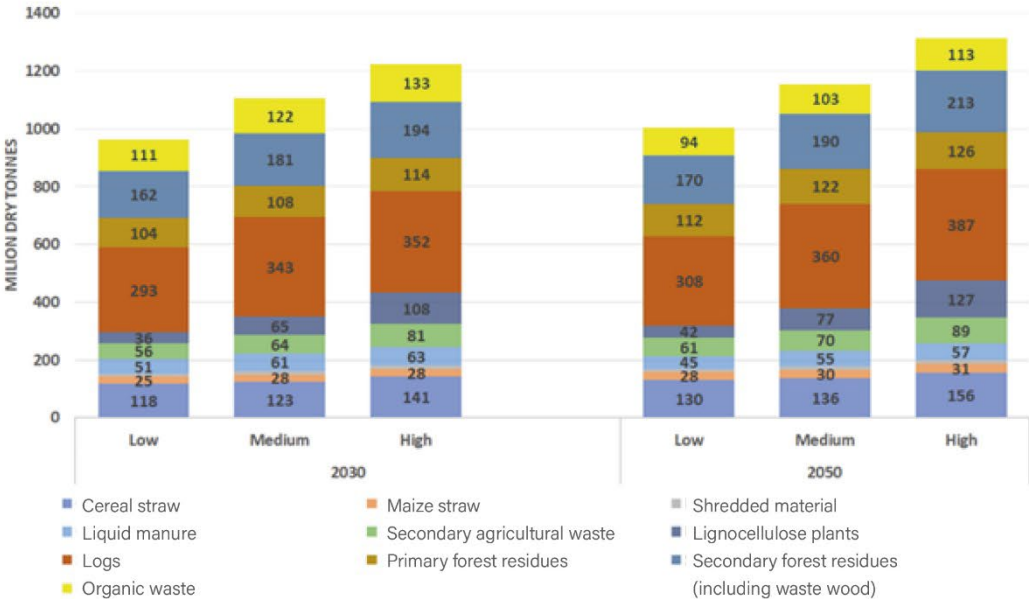
The limited availability of biomass tends to be used as justification to downplay the importance of low greenhouse gas biofuels. A new study from England entitled [„Sustainable biomass availability in the EU to 2050“](#) zeichnet hier ein gänzlich anderes Bild paints a completely different picture.

The study's authors conclude that up to 175 million tons of advanced and waste-based biofuels can be produced annually in Europe by 2050 - without harming biodiversity!

Production capacity of up to 175 million tons of biofuels

Even if parts of the biomass feedstock are used for the energy, industry, and household sectors, the share for transport in 2050 should be sufficient to produce up to 135 million tons of biofuels. Including biomass imports into the EU, production capacity could reach up to 175 million tons of biofuels.

Assessment of the availability of sustainable raw materials in three different scenarios (low, medium and high mobilisation of raw materials)



The assessment of the biomass potential is a result of very conservative assumptions. There is an additional potential of sustainable biomass feedstocks for renewable energies that have not been included in the calculations. Because, among other reasons, the raw materials have not yet been mentioned in the annexes of the Renewable Energy Directive (REDII) [Renewable Energy-Guideline \(REDII\)](#). Therefore, the biomass potentials in the future could be significantly higher than estimated in the study.

No-Regret-Option

In addition, low-carbon biofuels offer a "no-regret" option due to short- and long-term benefits:

- Scaling up production capacities will successively reduce the cost of biofuels.
- The internal combustion engine fleet can operate with low greenhouse gas emissions.
- Over time, the decline in demand for liquid fuels from road transport will enable a growing supply for aviation and marine transport at competitive prices.

Advanced and waste-based biofuels, together with other biofuels with a low [iLUC-risk](#) (indirect land-use change), can thus play a key role in decarbonizing EU transport in line with the 2050 climate neutrality target.

Conclusion: The future lies in advanced biodiesel

Sustainably produced biodiesel is the most readily available option for switching to renewable energies in the transportation sector. However, the energy transition driven by EU targets cannot be achieved through electromobility alone.

With the revision of the Renewable Energy Directive (RED II), the EU is setting the political framework for the increased use of waste and residual materials to produce biodiesel.

In addition, the combination of high oil prices, public subsidies, and rising CO₂ taxes is making sustainably produced biodiesel economical again.

BIODIESEL BLENDING QUALITY ACCORDING TO EN 14214

To comply with the standard for fossil diesel fuel (EN 590), mineral oil producers may only blend biodiesel that complies with the biodiesel standard EN 14214. The specified limits of the nearly 30 parameters define the minimum requirements of fatty acid methyl ester (FAME) for use as a fuel for diesel engines. All the parameters, purity, and biodiesel blending quality are guaranteed if the end product meets.

Inferior raw materials influence parameters

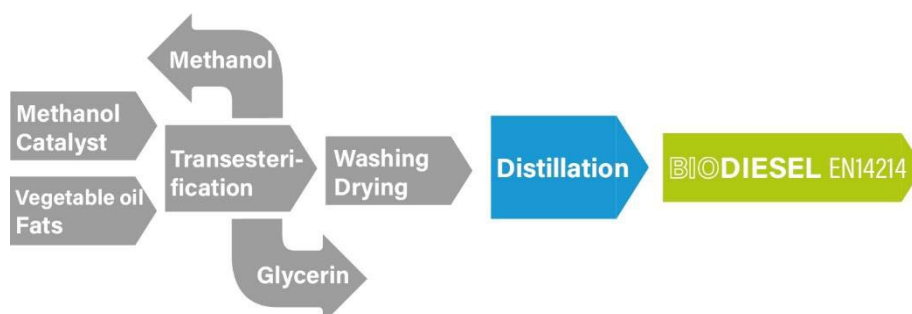
The use of lower quality raw materials affects the fatty acid patterns of the produced ester with significant consequences on various parameters in the EN 14214 standard. This applies in particular to the ester content and the sulfur content:

- **Ester content:** EN 14214 requires a fatty acid methyl ester content of at least 95.5 %. If fatty acids from waste products are applied, conventional processes cannot achieve this required ester content.
- **Sulfur content:** One disadvantage of waste and residual materials for the production of standard-compliant biodiesel is their high sulfur content. Sulfur content is limited to 10 ppm.

Although the transesterification reaction can improve the FAME quality, it is not sufficient to meet the parameters of EN 14214.

Guaranteed blending quality through distillation

Therefore, to produce standard-compliant biodiesel with the appropriate purity, crude biodiesel must undergo final purification by distillation if low-quality feedstocks are used. One process that is particularly suitable for achieving the standard-compliant biodiesel blending quality is short-path distillation.



THE SHORT-PATH DISTILLATION TECHNOLOGY

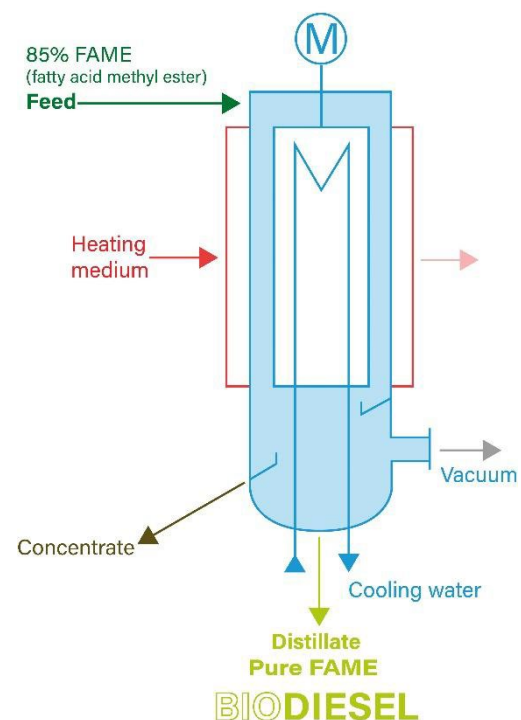
The one-step process achieves excellent results in distillation separation of thermally sensitive products such as biodiesel. The underlying technology enables efficient separation of even complex substances and achieves ester contents of up to 99 % in the distillate, depending on the feedstock.

Gentle evaporation due to built-in condenser

With the help of a built-in condenser in the apparatus, the path of the vapors between evaporation and condensation is extremely shortened. It leads to a gentle evaporation process in a fine vacuum with low-pressure loss at the same time. By selecting the optimum heating surface, wiper blades, and operating parameters, evaporation processes can be achieved in a way that is exceptionally gentle on the product. Moreover: Compared to rectification columns, the short-path evaporator is not only a much gentler but also a more cost-effective and less complex process in the biodiesel distillation field.

Further advantages of the short-path evaporator are:

- Short reaction and residence times
- Low pressure drop despite high evaporation rate
- High boilers do not reach the condenser thanks to efficient droplet separators in the apparatus
- High resource efficiency
- Uncomplicated cleaning and maintenance
- Minimal fouling effect
- High flexibility due to dynamic operation
- Water clear product
- Safety of the blending quality
- Special fixtures make it possible to process different viscosities and thus obtain additional varied products.



In terms of raw material input, this process can be used for biodiesel made from fresh vegetable oils and lower-quality raw materials such as used cooking oils, grease trap fats, and animal fats.

FAME yield of up to 99 % using short-path distillation

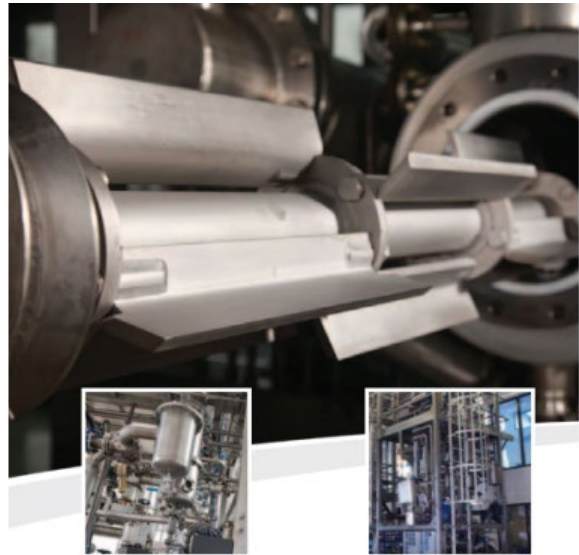
GIG Karasek's short-path evaporator makes it possible to process large feed volumes gently, continuously, and efficiently separate sulfur, polymers, and other impurities.

Up to 99 % of the valuable material can be recovered from the raw biodiesel using this process while at the same time complying with all parameters of EN 14214.

Purification in the short-path evaporator is comparable to a filter, which can work better or worse depending on the FAME feed.

The achievable yield also depends on the pre-process and raw material used.

Natural products, such as used cooking oils, are very heterogeneous in their composition and are subject to substantial-quality fluctuations.



However, with the optimum setting of the operating parameters, it is possible to get 99 % of the ester out of the raw biodiesel for most feedstocks.

Conclusion: Biodiesel distillation from a single source

The Short-Path Technology guarantees biodiesel blending quality, and enables ester contents that exceed the standard. With a FAME yield of up to 99 %, the evaporator also operates very efficiently with raw materials. In addition, GIG Karasek's pilot plant offers you the possibility to test your feedstock for its quality and blending capability in an uncomplicated way.

Technical center: Test infrastructure for Short-Path evaporators

GIG Karasek's, technical center has its own test and development facility. The extensive test infrastructure serves as an indispensable platform for developing individual apparatuses or entire plants, and for the optimization of operating data of existing distillation plants.

The technical center conducts all test processes which are supervised by specialists. Before the trials begin, detailed planning is carried out in cooperation with the customer, and is thereafter simulated in a laboratory or tested on a pilot scale. The data required for the scale-up is determined in the process. With the methods developed through many years of experience, operations can be performed that exceed the scale-up factor 2000.

Distillation-Plant layout

The entire range of evaporation and distillation technology is provided in the pilot plant. Given its many apparatuses, it is possible to determine the optimal plant configuration or the number of separation apparatuses required in the overall plant. A variety of different processes and procedures can be simulated and optimized. Ultimately, the best possible solution is achieved within the given conditions.

Checking the blending quality of a feed

At GIG Karasek, customers, interested parties, and business partners have the opportunity to have their biodiesel feedstock purified on a test basis in a short-path evaporator to evaluate the blending quality of their feedstock:

- About 300 to 500 liters of the feedstock are required for the test series in the pilot plant.
- The tests are carried out at pressures and temperatures that have proven to be effective based on hundreds of test series.
- Once the tests are completed, the customer normally receives 30 to 40 samples for further analysis, including the pilot plant report with all relevant test data (temperature, pressure, throughput, energy consumption).

Based on the test protocols, the plant operator has a solid foundation to adjust the evaporator for the respective feedstock.

Use case & the scope of services of the plant

In principle, GIG Karasek's range of supplies for a biodiesel plant includes the evaporator, the degasser stage, the necessary conveying elements, the vacuum system, and heat exchangers required for heat recovery and efficient operation of the plant. Also included are the internal piping, the EMSR technology (on request also with on-site control) as well as insulation and steel construction on customer request.

All mentioned components are provided at the plant by us or by the customer or third parties, depending on the customer's specification. Energy supply (heat, cold) and compressed air and nitrogen supply should be made available by the customer.

Use Case: Optimization of a biodiesel plant according to EN 14214

In plants that have been in operation for a long time, the tasks often change over time, or particular bottlenecks make it necessary to modernize the plant

Such was the case with a classically built 65,000-ton biodiesel plant which initially operated on used cooking oils and fresh oils. However, the plant was supposed to be rebuilt entirely, to produce standard-compliant biodiesel from waste products under EN 14214 specifications.

Test series in the technical center

Since the factory was still under reconstruction, the customer created a "theoretical" biodiesel product to test the effectiveness of the short-path evaporator in the GIG Karasek pilot plant.

The heavily contaminated, black-colored model liquid was brought into our test plant and evaporated. The result was a crystal-clear, distilled product that met all the requirements of the EN 14214 specifications.

Further pilot plant test series followed to simulate the distillation process on a pilot scale to determine the optimum design of the plant and the data required for the scale-up operation.

On completion of the renovation work, the biodiesel plant produced standard-compliant biodiesel with an ester content of 98 %. As a result, they quickly earned the name of a "Premium Biodiesel Producer" on the market.

Project procedure Short-Path evaporator

A project engineer accompanied the process from consulting and planning to the commission of the short-path evaporator. However, the project procedure was unusual for this customer, as GIG Karasek exclusively handled the planning and construction of the short-path evaporator and the technical support for the plant. All other plant components associated with the evaporator were planned and built by the customer during the factory reconstruction.



The three biggest problems in biodiesel construction

During biodiesel distillation operations, many factors have to be taken into account to ensure the quality of the biodiesel produced. The type and quality of the raw material play a decisive role.

1. High sulfur content in biodiesel

FAME from vegetable raw materials only contain 2 to 7 mg/kg sulfur content. Animal fats and used cooking fats contain 30 mg/kg sulfur. Food waste, in particular, sometimes has a high input of sulfur, since foods such as eggs, dairy products or poultry carcasses contain a lot of sulfur.

- It is essential to remove the high-boiling impurities from biodiesel through distillation in order to meet the requirements of EN 14214.
- As a result, a significant reduction in sulfur content and other impurities such as phosphorus, unsaponifiable matter, or polyethylene can be accomplished.
- Higher sulfur contents also make it necessary to customize biodiesel distillation by varying the conditions.
- Highly volatile sulfur compounds (mercaptans) could quickly push the vacuum system to its limits if not properly accounted for in the suction flow.

Consequently, depending on the sulfur content, the biodiesel distillation must be run with a lower load or a higher residue rate, resulting in a correspondingly lower throughput and yield.

2. Various composition and quality of raw materials

One of the biggest challenges in biodiesel distillation is the uncertain standardization depending on the lipid source. Since the composition of the basic materials provided varies, there are sometimes considerable differences in the quality:

- Compared to separately collected used cooking oils, used cooking fats and oils from grease separators, for example, are significantly poorer in quality.
- In most cases, the characteristics of "the same products" from different origins vary.

- The plant operator must take the raw material composition into account during operation and compensate for it by constantly adjusting the plant parameters.
- For many products, it is necessary to determine the most suitable operating parameters for the evaporation process by conducting a series of tests.

A key factor for the design of evaporators in the context of biodiesel distillation, for example, is the viscosity of the processed materials. The more viscous the product, the lower the feed rate, i.e. the throughput.

The reason is the long residence time for the product to be converted to a lower viscosity state. Which is done by preheating in the evaporator or suitable heat exchangers using waste heat recovery before starting the evaporation process.



3. The higher complexity of biodiesel distillation plants

In some cases, the composition of the feedstocks makes it necessary to design the biodiesel plant as a whole in a more complex way and to connect several evaporators in series.

In particular, low-quality raw materials and multi-component mixtures such as tall oil, place high demands on the plant's design. The number of separation apparatuses required in the overall plant should be optimally established by a comprehensive test series.

For example, the first separation stage, when the viscosity is still very low, a falling film evaporator could be used to separate aqueous substances.

When the mixture reaches a higher density or evaporation is no longer feasible due to temperature sensitivity or other factors, the wiped surfaces of the thin film or short-path evaporator are used, in the second stage.

Conclusion: Individual solutions for biodiesel distillation

Raw material-specific challenges in context of setting up and operating a biodiesel distillation plant vary from company to company. Consequently, standard applications are not feasible. Depending on the type and quality of the raw material, different processes are used which are optimally aligned to the needs of the plant operator.

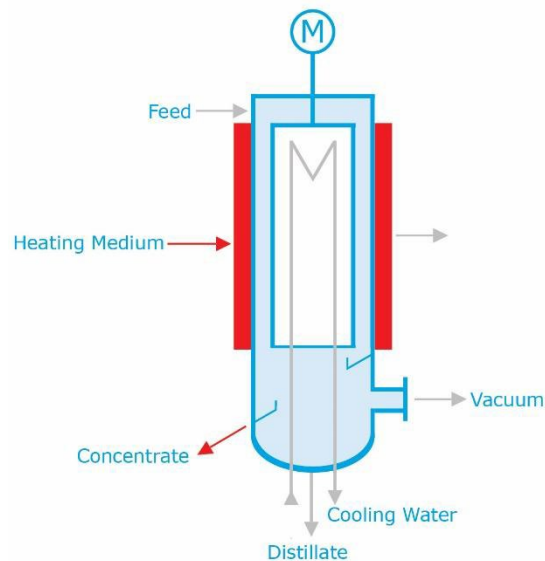
SHORT-PATH EVAPORATOR VERSUS RECTIFICATION COLUMN

As part of international efforts to achieve sustainable development, biodiesel production from raw materials such as used cooking oils and fats is becoming increasingly important. However, not every process is equally suitable for biodiesel distillation. A comparison of the two processes highlights the benefits of the short-path evaporator regarding effectiveness, flexibility, cleaning, as well as operating and investment costs.

Short-Path Distillation: One-Stage Process

The short-path evaporator combines a thin film evaporator and condenser in a single apparatus:

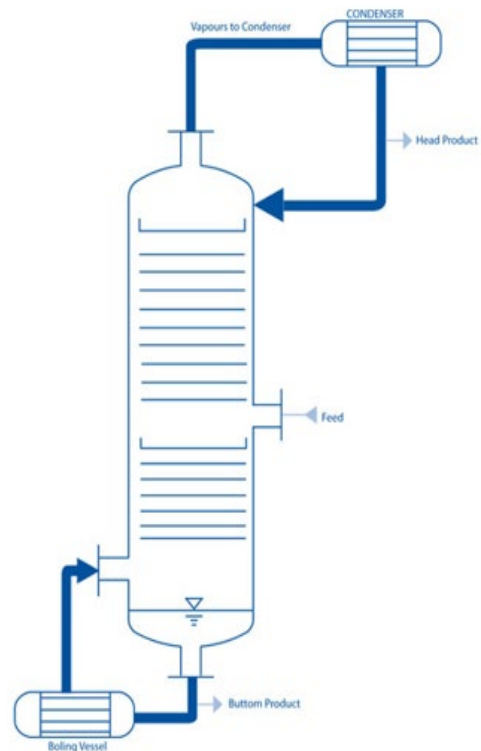
- It consists of a vertical body with an external heating jacket, a rotor with movable self-adjusting wiper elements, and an internal condenser.
- It is possible to process different viscosities through special built-in components and thus process more varied products.
- The internally rotating rotor system distributes the mixture of substances fed in via the wiper system on the heated evaporator wall, in order to evaporate the low-boiling components.
- The vapors are condensed spontaneously in the built-in condenser, and discharged as distillate.
- High boiler droplets do not reach the condenser thanks to efficient droplet separation in the apparatus.
- The non-condensed product vapors and inert gases enter the vacuum system through the vacuum nozzle via the cold trap.
- The non-evaporated, liquid product portion flows as film into the lower section of the short-path evaporator, is collected in a tray and leaves it after a short time via the product outlet.



Rectification: Multi-stage process

In the rectification process, liquids with two or more components are separated through multiple evaporation and condensation stages.

- The repetitive processes take place in a vertical rectification column. As a result, the rising vapor stream and the down-flowing condensate stream are in constant material and heat exchange (countercurrent principle).
- By supplying thermal energy, the liquid mixture which is to be separated, is brought to boiling point in the re-boiler at the bottom of the column.
- The more volatile components, evaporate, rise in the column and liquefy in the downstream condenser.
- In contrast to the short-path evaporator, only a portion of the overhead condensate is withdrawn and collected. At the same time, the rest is fed back into the column head as reflux.
- Built-in components in the form of structured or non-structured packings are used to intensify the exchange between gas and liquid. These are usually various metal fabric or plastic rings to increase the surface area critical to the separation process.



Advantages of the Short-Path technology

Rectification columns are a tried-and-tested technology for producing biodiesel of specification-compliant quality. The short-path technology also offers the possibility of getting the best quality out of resources and products, even with high viscosity and heavily soiled products such as biodiesel

1. High effectiveness of short-path evaporation

The multi-stage rectification column has advantages where fractions must be separated, and a higher degree of purities must be produced. Typical application areas are primarily the petrochemical industry and the large-scale production of basic chemicals. The separation via column is a very complex process, which is also extremely difficult and cost-intensive to operate.

For biodiesel distillation, rectification columns are oversized and downright luxurious, requiring only one separation step between heavy and light boilers. As a result, the thermal separation of only two components can be achieved much more effectively and, above all, cost-efficiently with single-stage short-path distillation.

2. Gentle evaporation for thermally sensitive products

A significant advantage of the single-stage short-path technology is that it ensures product quality through minimal temperature load and short residence times:

- The built-in condenser minimizes the path of the vapors between evaporation and condensation and leads to a gentler evaporation process in the fine vacuum.
- Heat-sensitive products such as plant-based or meat-based oils tend to decompose or react undesirably during processes in conventional evaporators. In order to avoid this, the product is distilled in a fine vacuum between 1 and 0.001 mbara at a high evaporation rate.
- By lowering the working pressure, a considerable reduction of the evaporation temperature is ensured so that even sensitive organic substances such as biodiesel can be separated gently.

Due to the built-in components and the reflux ratio, the mixtures remain in the rectification column for a significantly longer time. Unfortunately, this is also associated with undesirable side effects. The operation of the short-path evaporator thus enables a much more product-friendly and stable process for particularly sensitive products such as biodiesel.

3. Minimal pressure loss despite high evaporation rate

Short-path evaporators have a very low pressure loss in the system because the condenser is placed directly inside the evaporator shell. The optimized evaporator geometry reduces the pressure loss between evaporator and condenser to negligible values while maintaining a high evaporation rate.

However, there is a resistance in a rectification column due to the column internals and the geometry, and outflowing return. Therefore, the unhindered flow of the vapors is restricted which, depending on the type and number of column internals, leads to a respective pressure loss.

4. High flexibility due to dynamic operation

A column must be run as a static system over several days until a stable condition is established. If problems occur in the pre-process, this will affect the column very quickly and for a long time. However, rapid adaptation is not possible since the column reacts only very slowly to changes in input substances and input concentrations.

With a short-path evaporator, on the other hand, a much more dynamic operation is possible with single-stage separation processes, thereby offering numerous advantages, especially for raw biodiesel, which may vary greatly in composition. For example, different flow rates can be set, heating reduced or increased, or the rotor speed influenced.

Moreover, with short-path evaporators, necessary adjustments to fluctuating compositions of the feedstock can be carried out without having to disassemble the plant manually, as may be the case with a column. The operation can be interrupted and restarted if necessary. Batch operation is thereby possible.

5. Fouling effect is minimized with the short-path evaporator

A rectification column usually runs for a year or more without shutting down, especially with natural products such as biodiesel, which favors the undesirable formation of deposits on the surfaces of the column packings (fouling). As a result, the heat transfer efficiency decreases, the pressure drop increases and the separation quality decrease.

This enormous disadvantage is eliminated with biodiesel distillation in the short-path evaporator. The rotating design prevents fouling in the formation process. In addition,

the wiper blades continuously sweep along the film on the heating wall, thereby ensuring continuous fluid-mechanical cleaning of the heating surface.



The wiper blades of the short-path evaporator continuously clean the heating surface, making it ideal for fouling applications. © GIG Karasek

6. Uncomplicated cleaning and maintenance

Both distillation systems have to be shut down once a year for maintenance purposes. However, additional shutdowns and cleanings are impossible with the column without strongly influencing the operation. In contrast, a short-path evaporator can be cleaned very easily even during the year by filling it with a cleaning agent and slowly rotating rotors the rotor.

The short-path evaporator also offers advantages in terms of cleaning time. While the cleaning effort for a short-path evaporator takes only a few hours, the cleaning of columns takes at least several days. For the cleaning of large columns, whose packages have to be lifted out by crane for this purpose, a shutdown of the plant for several weeks has to be estimated.

7. Double to triple lower operating costs

The operating costs of both separation processes are determined by up to 95 % energy consumption. The rectification column amounts to twice to three times that of an equivalent short-path evaporator, depending on the reflux ratio.

The following applies:

- The lower the number of column stages, the higher the required reflux ratio to obtain the desired degrees of separation and purity.
- The higher the reflux ratio, the higher the specific thermal energy consumption of a column because more liquid has to be „circulated.“
- A high reflux ratio is also associated with an increase in the column diameter.

The rectification columns can be constructed using large diameters to achieve high throughputs. However, short-path evaporators are limited by geometry with a maximum evaporator area of 80 m².

Therefore, higher throughput levels can be achieved by connecting several short-path evaporators next to or after each other.

Depending on the task at hand, it is necessary to assess each case and to weigh the advantages. Although a column enables a higher throughput level, it is also associated with significantly higher energy costs.

Investment costs: Short-Path evaporator is considerably cheaper

GIG Karasek develops individual, tailor-made solutions and plants, which are designed based on the feed quantity. The comparison of two equivalent plants with a feed quantity of 7.5 tons/hour which, results in a cost ratio of 3.5 to 1 in favor of the short-path evaporator at current material prices. The equipment required for evaporation, substance separation, and condensation is included in the calculation.

The drastic difference in investment is determined, on the one hand, by the high costs of the column packings, and on the other hand, the column, must be largely built, compared to the short-path evaporator. The latter drives up the material costs of the rectification column due to the difference in weight and steel tonnage.

Conclusion: Effective Biodiesel Distillation with the Short-Path Evaporator

Using a rectification column for biodiesel distillation is like using a sledgehammer to crack a nut. The process is suboptimal for applications with only one separation cut-off, as it is very time-consuming and expensive. A short-path evaporator not only enables gentler stock separation but also offers a higher degree of flexibility and effectiveness. Easy cleaning and significantly lower operating and investment costs are further advantages of the short-path technology.



