PÖRNER GRUPPE

PTX FUELS®

Long-term supply to German aviation industry of synthetic kerosene (eSAF) from renewable power, hydrogen and sustainable carbon sources

A project of EDL Anlagenbau Gesellschaft mbH Leipzig

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Executive Summary

Sustainability goals of the German aviation industry

- Stepwise substitution of Jet A-1 by adding SAF until the year 2030.
- ZERO EMISSIONS: Climate-neutral air transport by using 100% SAF and new propulsion technologies (electric propulsion, hydrogen-based propulsion) until 2050.

Development of demand

- Rising demand for SAF due to statutory blending quota for Jet A-1.
- Increasing customer requirements for emission-free airfreight transport.

Challenges

- HEFA kerosene cannot meet the needs due to a limited availability of raw material. Stricter sustainability criteria of EU-RED II further limit the use of biomass (plant oils).
- Resource scarcity when it comes to animal raw materials and used cooking oil as well as margin competition with synthetic diesel lead to price increases (arbitrage) on a volatile raw material market.

EDL's approach

- Use of the most advanced synthetic kerosene (eSAF) with the highest CO_2 savings from hydrogen-based **PtX Fuels®** as "base-load capable" supply of the German aviation industry from local production, with over 85% reduction of greenhouse gases (GHG) and long-term price smoothing!
- PtL kerosene certificates must be freely tradable acc. to the book & claim system. Based on the value of the PtL certificates they have to reflect the higher production cost of fuel compared to other SAF sorts and need to be encouraged politically in Europe with a higher weighting factor.

Starting Position

- Due to the introduction of a blend quota for SAF in Jet A-1, SAF is blended with kerosene by mineral oil companies “ex refinery” and delivered as mixture to commercial airports in Germany.

- The SAF blend is integrated in the existing price model of moving monthly prices and the higher production cost is compensated by additional purchase of SAF in form of a higher formula price.

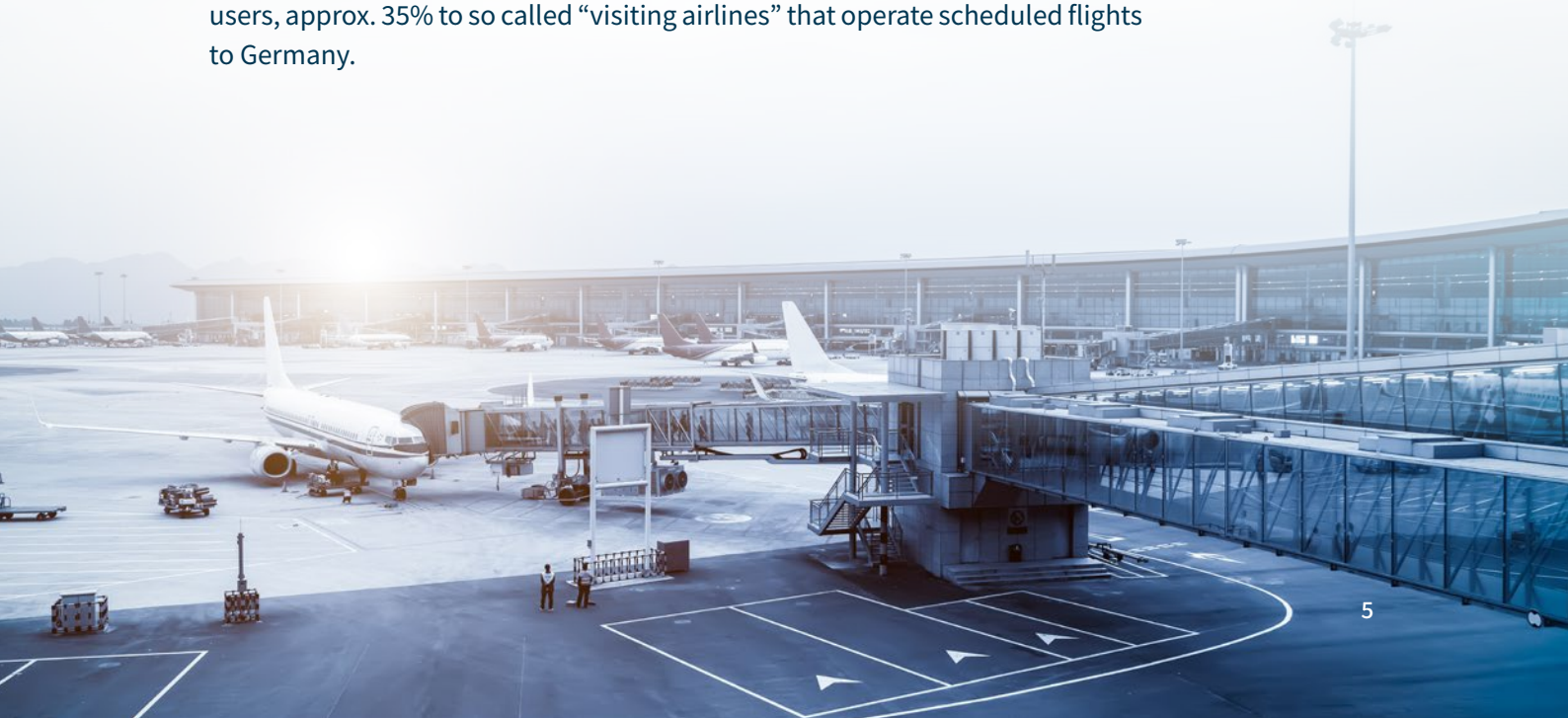
- With the introduction of a statutory sub-quota for PtL kerosene (eSAF) German commercial airports will need approx. 200,000 t of eSAF as separate admixture to Jet A-1 in 2030 irrespective of other SAF sorts, such as HEFA and AtJ.

- Since all eSAF distributors will have to meet the PtL sub-quota from the year 2026, the voluntary trading with PtL certificates represents a cost-cutting solution because eSAF does not have to be physically transported through Germany to refinery sites and from there as mixture to the airports.

- The book & claim system provides the opportunity to feed in eSAF physically at one or two major airports only; eSAF certificates can – depending on the production output – however be split as need be and distributors can sell them to airlines in the scope of their quota-compliant eSAF quantities.

- For this reason, the integration of eSAF quantities into the formula price model of oil companies can be omitted.

- Approx. 65% of about 200,000 t of eSAF are allotted to German airlines as end users, approx. 35% to so called “visiting airlines” that operate scheduled flights to Germany.



EDL's Unique Selling Propositions for eSAF PtX Fuels®

- For the eSAF quantity of 50,000 t required in Germany in 2026 and 200,000 t in 2030, only 2–3 PtL plants are expected to be built and operated due to the production costs. The quantities produced are transported to the distributors and mixed into the Jet A-1 at their refinery sites. This results in higher costs for air traffic and a worsened emissions balance without any added value.

- With more than 100 years of engineering expertise in refinery and plant construction, EDL will produce the eSAF quantity of 50,000 t **PtX Fuels®** required for 2026 at the plant in Böhlen-Lippendorf. The innovative plant design enables the system to be operated emission-free in terms of the eco-balance by completely utilizing the process gases within the system. With the expansion stage (75,000 t/a), more than 50% of the PtL quantity required in 2030 will be available in Germany as early as 2026 at optimal production costs for customers.

- With the construction of another plant at a German refinery site, EDL will be able to provide the total requirement of 200,000 t to meet the German PtL kerosene sub-quota, produce it at optimal costs and put it in circulation at one or two selected airports with minimal emissions.

- For EDL's concept it has to be decided to which German airports the eSAF quantities can physically be delivered. With the support of one or two airlines, the total eSAF quantity can be released to these companies. The purchasers, however, pay the eSAF price only for the quantity required to meet their sub-quota. Certificates by name are issued for these quantities. The remaining free certificates are sold to other distributors of Jet A-1 to fulfil their quota obligation and resell eSAF certificates to their end users, even if the eSAF product is physically used at another airport or by another airline.

The Production Process of eSAF PtX Fuels®

- The HyKero production process developed by EDL deploys proven process technologies and allows a reliable and efficient production of the eSAF **PtX Fuels®**.
- The first HyKero plant for the production of 50,000 t per annum of eSAF will be built in the industrial park Böhlen-Lippendorf, south of Leipzig. The plant location offers optimal infrastructure conditions. Moreover, it is not far from the airport Leipzig-Halle.
- Green hydrogen required for the process is generated from water and renewable electricity in a 110 MW electrolysis facility.
- In further process stages, synthesis gas (H_2 + CO) is produced from green hydrogen (H_2) and sustainable carbon sources and processed further by applying Fischer-Tropsch synthesis and subsequent hydrocracking to become eSAF.
- The HyKero plant has been designed as “ZERO EMISSIONS” plant and is thus almost free of emissions.
- The resulting eSAF will be provided with all necessary additives so that it can be blended with Jet A-1 as sustainable “drop-in” aviation turbine fuel acc. to ASTM D1655.
- At present, the construction of PV and wind power facilities close to the HyKero plant location is checked to supply affordable self-generated renewable electricity for internal consumption.

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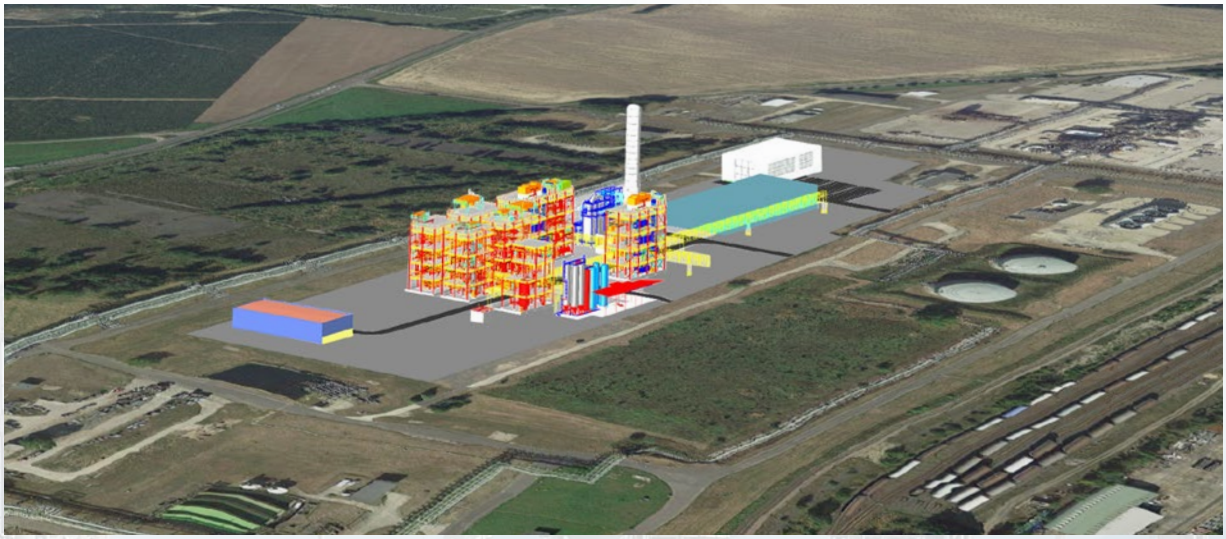

About EDL

EDL Anlagenbau Gesellschaft mbH is one of the leading, technology-oriented plant engineering companies in Germany and looks back on more than 100 years of company history of Edeleanu and Chemieanlagenbau Leipzig-Grimma. Since 2003 EDL has been part of the Austrian Pörner Group after many years as subsidiary of RWE/DEA and Texaco.

EDL's expertise focuses on process-related plant engineering. Customers are in the refinery, petrochemical and chemical industry. Since many decades, EDL has been developing smart and sustainable concepts and solutions for the process industry. Hundreds of successfully implemented greenfield, expansion and brownfield projects show proof of the specialist competence, professionalism and reliability of the company.

As a technology-driven company and system integrator EDL develops industrial solutions for the production of power-based Sustainable Aviation Fuels (eSAF). **PtX Fuels®** is such eSAF that is also known in the aviation sector as PtL kerosene.

EDL is member of numerous initiatives and has committed itself to promote the production and use of eSAF. Among others, EDL is member of the German Aviation Initiative aireg e.V., Berlin, the Clean Skies for Tomorrow initiative of the World Economic Forum, Geneva, the workgroup Power-to-X for Applications of the German Engineering Association VDMA, Frankfurt, and supports the European Clean Hydrogen Alliance (ech2a).

Sustainable Aviation Fuels

The Market Situation for SAF

Historical development

- Approval of FT-SPK (BtL) in 2009; approval of HEFA in 2011.
- Little availability of quantities at high prices have a prohibitive impact on the demand-related behaviour.
- Practical test by Lufthansa over seven months in 2011 where 40% were financed from federal funds.
- Worldwide few SAF flights. SAF market collapsed in 2014 at a crude oil price of 40 USD/bbl.

Turnaround in 2019

- “Fridays-for-future” puts climate policy in the transport sector on the agenda again.
- CORSIA agreement on a global emission trading system in aviation.
- EU-RED II tightens the demands for the raw materials and production of SAF.
- The airfreight business becomes the pioneer of energy transition in aviation.
- The USA step up their efforts to launch SAF: ASTM approves further production methods. US airlines sign long-term supply agreements for SAF and the market launch is promoted by a tax imputation system for SAF kerosene quantities by so called “RIN” in form of tax credits.
- In Europe, Deutsche Post DHL Group signs a long-term supply contract for HEFA kerosene and thus substantiates its sustainability goals for climate-neutral air transport in the long run.

Current SAF Procurement Alternatives

Looking at the portfolio of current SAF production processes

- HEFA and AtJ are available at short notice.
- The expected demand cannot be met by the existing production facilities. Both processes are heavily dependent on the relevant resource base.
- Every shortage of the resource base has a price increasing effect. Investments in the raw material production are more profitable than the investment in production facilities.

Looking at the eSAF PtX Fuels® portfolio

- eSAF from scaled production will be available from the year 2026 and is on the growth path of the product lifecycle.
- The raw material basis is uncomplicated and secured.
- The production process is technologically mature with higher production costs compared to the current HEFA/AtJ production.
- The German sub-quota of “advanced biofuels” secures the market in competition.
- eSAF is currently the only manufacturing process that consistenly achieves GHG emission savings of more than 80%. EDL’s production process is emission-neutral, but emissions from the preceding chain or preliminary products are included in the GHG calculation. With an optimized supply and process chain PtX Fuels® reaches emission reductions of more than 90%.

Hydrogen-based technologies are popular as investment vehicle.

The HyKero Project for the Production of the eSAF PtX Fuels®

- EDL Anlagenbau Gesellschaft mbH will implement in cooperation with renowned partners the construction and operation of the HyKero plant for the production of eSAF under the brand name **PtX Fuels®** at the Böhlen-Lippendorf industrial site.
- The eSAF **PtX Fuels®** meets the requirements of the approval standard ASTM D7566 Annex 1 and has been approved for a blend with Jet A-1 up to 50%.
- The eSAF is produced from hydrogen and sustainable carbon sources by using green power.
- The effective CO_2 emission reduction is more than 85% (remaining emissions result from the preceding chain) and thus far above the GHG emission minimum value of 70% for SAF!
- Because of the good geographical location of the production site in the Leipzig region, several commercial airports (or refinery sites) can be reached with road tanker and/or rail tanker transport. GHG emissions related to the transport are very low. As regards the maximum possible avoidance of emissions, the eSAF **PtX Fuels®** should physically flown out via two or three airports only.
- The initial eSAF production quantity designed is 50,000 t and can be extended at the Böhlen-Lippendorf site by another 75,000 t.
- For another 75,000 t there is an option at a German refinery site. Thus, EDL will be capable of producing the total quantity of eSAF needed in Germany for all German distributors from the year 2030.

The Böhlen-Lippendorf Production Site

- eSAF is produced on own premises at the industrial park Böhlen-Lippendorf.
- The site has been plan-approved and is suitable for the production of liquid hydrocarbons.
- In addition, the hydrogen production will be connected to the hydrogen pipeline ring Leipzig (LHyVE). This ring, on the other hand, is connected to the European hydrogen backbone and thus provides additional security of supply for the HyKero plant and higher flexibility of the hydrogen production. The HyKero plant has access to the existing railway siding for rail tanker transport as well as for road tanker loading for road transport.
- The set-up of the eSAF production at Böhlen-Lippendorf is funded by the Free State of Saxony as well as by the German government.
- The partial projects “LHyVE production DE17” and “LHyVE HyKero DE72” are subsidized under the EU funding regime IPCEI hydrogen.

List of Abbreviations

a	Annum (year)
ASTM	American Society for Testing and Materials
AtJ	Alcohol-to-Jet
bbl.	Barrel (barrel volume 156 liter)
BtL	Biomass-to-Liquid
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CO	Carbon monoxide
CO_2	Carbon dioxide
eSAF	Power-based Sustainable Aviation Fuels
EU	European Union
FT-SPK	Fischer-Tropsch Synthetic Paraffinic Kerosene
GHG	Greenhouse gas
HEFA	Hydrotreated Esters and Fatty Acids
H_2	Hydrogen
H_2O	Water
IPCEI	Important Project of Common European Interest
Jet A-1	Aviation turbine fuel
LHyVE	Leipzig Hydrogen Value Chain for Europe
MW	Megawatt
PtL	Power-to-Liquid
PV	Photovoltaic installation
RED II	Renewable Energy Directive (of EU)
SAF	Sustainable Aviation Fuels
t	Ton(s)

Imprint

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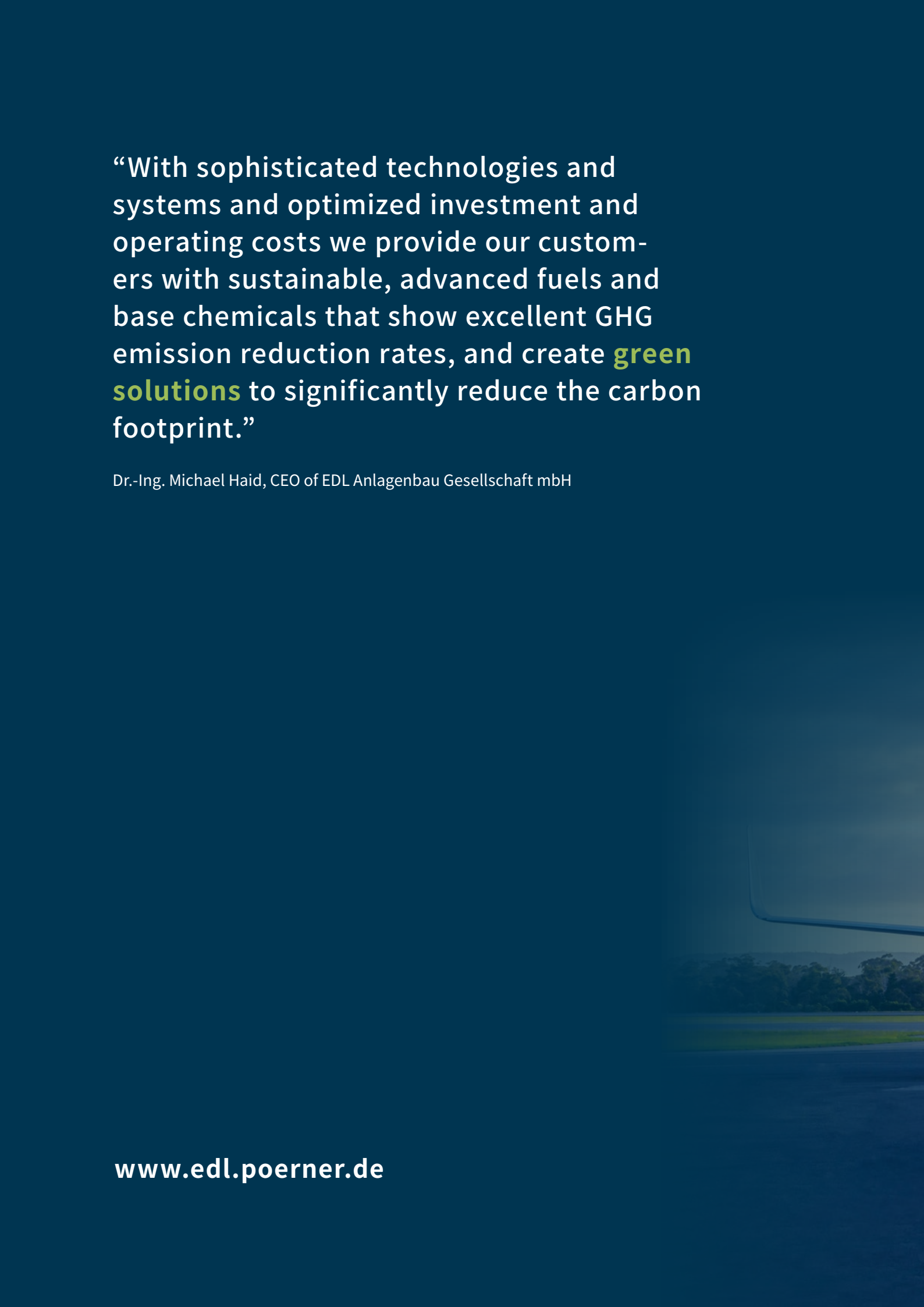
“With sophisticated technologies and systems and optimized investment and operating costs we provide our customers with sustainable, advanced fuels and base chemicals that show excellent GHG emission reduction rates, and create **green solutions** to significantly reduce the carbon footprint.”

Dr.-Ing. Michael Haid, CEO of EDL Anlagenbau Gesellschaft mbH



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