PAOs New Developments and Sustainability roadmap

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Creating a world of opportunity

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- Introduction to IMCD and Ineos Oligomers
- Automotive & Thermal management in Latin America
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- HV mPAO and cPAO comparison in Automotive Gear oils
- Sustainability - Scope 3: in use avoided emissions vs. Gp II
- Sustainability - ISCC+

IMCD is a leading global partner for the distribution and formulation of specialty chemicals and ingredients

€4,728
Revenue
(in € M)

>60
Countries

8
Business Groups

68,000
Customers

82
Market-focused Technical Centres & laboratories

5,126
Professionals

52,000
Products

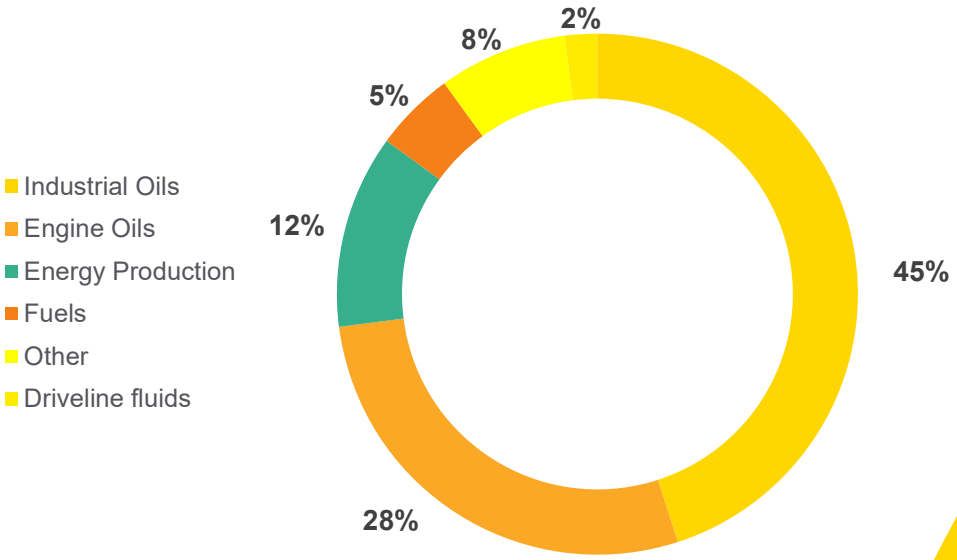
- Added value to the supply chain through expertise and innovation
- Comprehensive and complementary specialty portfolio
- Formulation and solutions provider
- Global footprint with local expertise in EMEA, Asia-Pacific and Americas

Overview 2024

Creating a world of opportunity

IMCD Lubricants & Energy

Revenue by market sector



Global

Sales experts • • • • • • • > 112

Active customers • • • • • >3374

Americas

Sales experts 35 Customers >1115

EMEA

Sales experts 47 Customers >1231

Asia-Pacific

Sales experts 30 Customers >1028

INEOS Group overview

- Ineos is a global chemical company whose products touch every aspect of modern day life: comprises 30 businesses with 173 sites in 32 countries in the world.

OLIGOMERS

$1,7 bn Sales (2023)

640 employees

4 Major product lines

- Linear Alpha Olefins (LAO)
- Poly Alpha Olefins (PAO)
- PolyButene (PIB)
- Specialty Oligomers (SO)

4 Commercial offices

6
sites worldwide

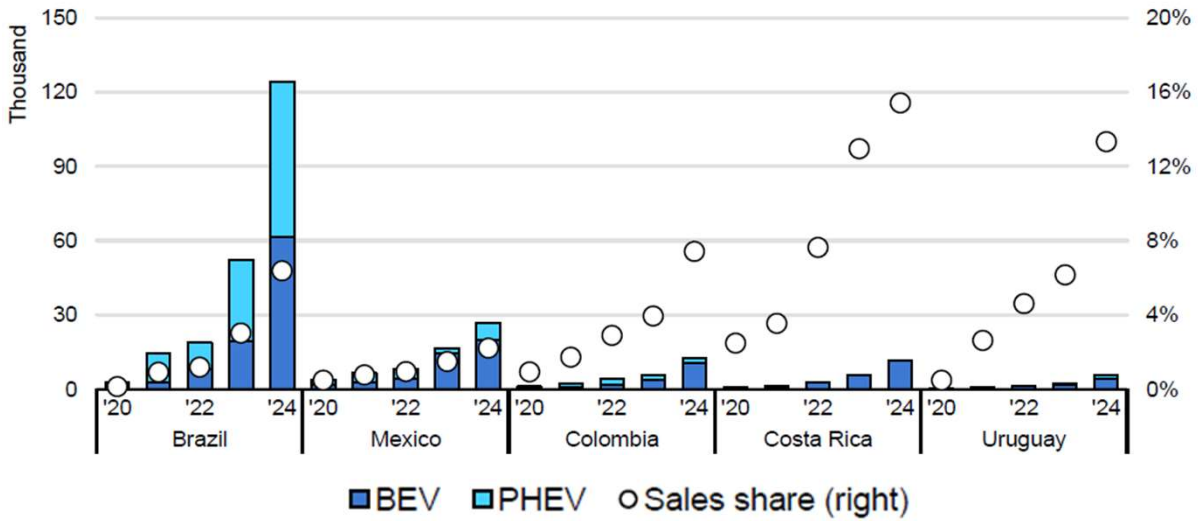
3 sites in Europe

3 sites in Americas

- Ineos is the world's largest marketer of PAO synthetic fluids
- **IMCD Group is the distributor of Ineos Oligomers PAOs in all Latin America**

Automotive & Thermal management Latin America

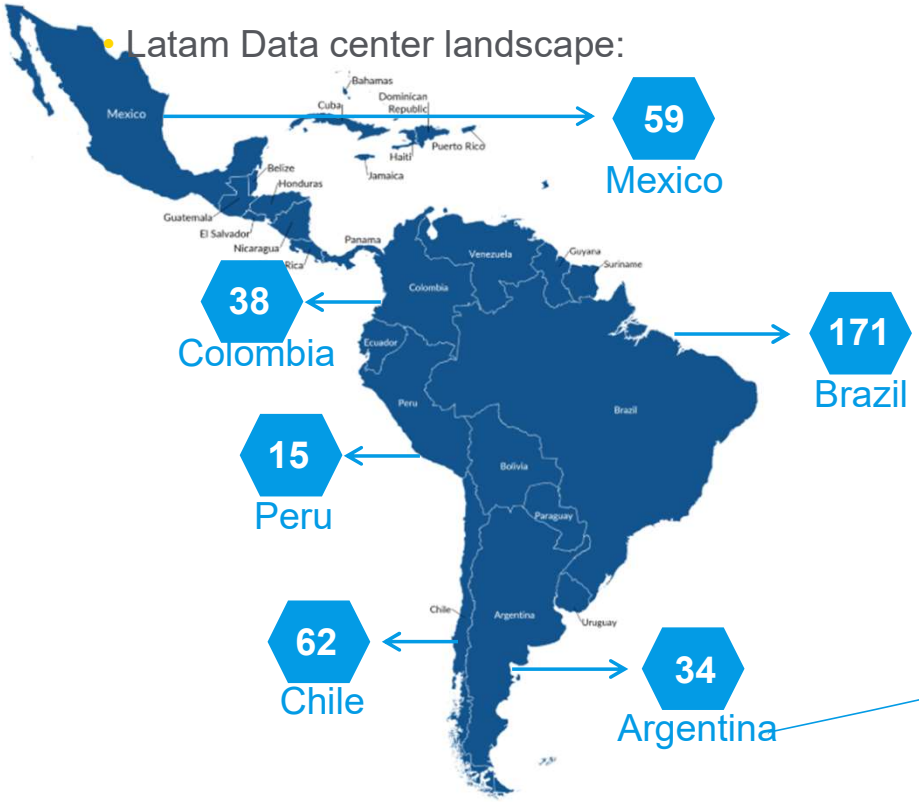
- **Automotive:** LV engine oils, (e)-driveline fluid
- 2024 Latam EV numbers:



BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle.

Source: Global EV Outlook 2024, IEA

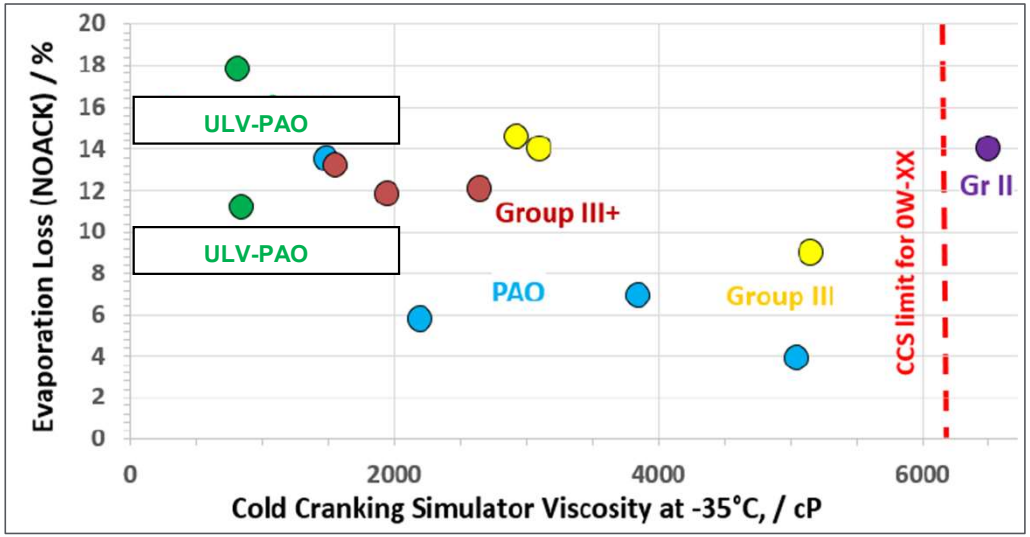
- **Thermal management:** (car) battery, e-motor, electronics, data centers.
- Latam Data center landscape:



Source: www.datacentermap.com

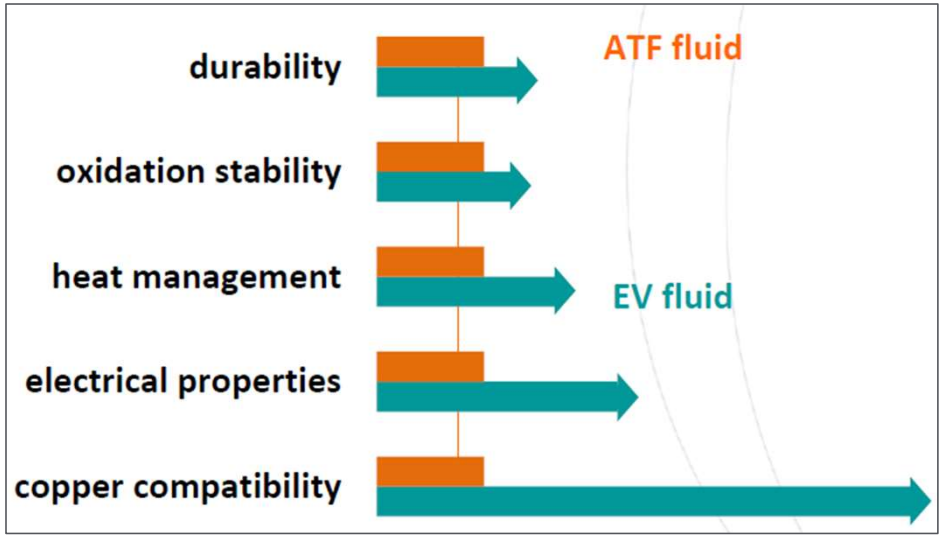
Ultra low viscosity PAO - Future technical requirements for Automotive

- Improved fuel efficiency



- Newest EO specifications require LV formulations. Lower viscosity can be achieved with LV base stocks. However, lower viscosity means higher NOACK volatility. New generation PAO fulfill both requirements.

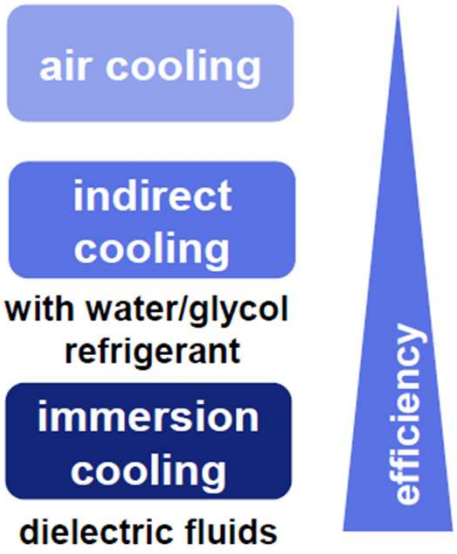
- Comparison of technical requirements of future EV fluid vs. existing ATF fluid



- E-driveline fluids need enhanced electrical and metal compatibility besides lubricating bearings and cooling the e-motors.

Ultra low viscosity PAO - Future technical requirements for Thermal management with dielectric fluids

- Improved efficiency



- Applications areas of immersion cooling

	sump	temp.
- data centers	~ 30L	30°C
- fuel cells	~ 25L	25°C
- battery	~ 7L	40°C
- charge stations	~ 0.5L	100°C
- e-motor	~ 1L	100°C
- power electronics	~ 1L	100°C

- Immersion coolants allows direct cooling and offers a more efficient cooling system with improved sustainability.
- In case of battery cooling the effect is reduced charging times, enhanced range, lower battery cost of EVs.

Ultra low viscosity PAO - PAO's fit for thermal management and EV driveline

• EV Driveline

- Beneficial electrical character
  - Low electrical conductivity
  - High breakdown voltage
- Suitable material properties
  - Oxidation and hydrolytic stability
  - Add-on: biodegradable
- Good frictional properties
- Commercially available in large quantities

• Thermal Management

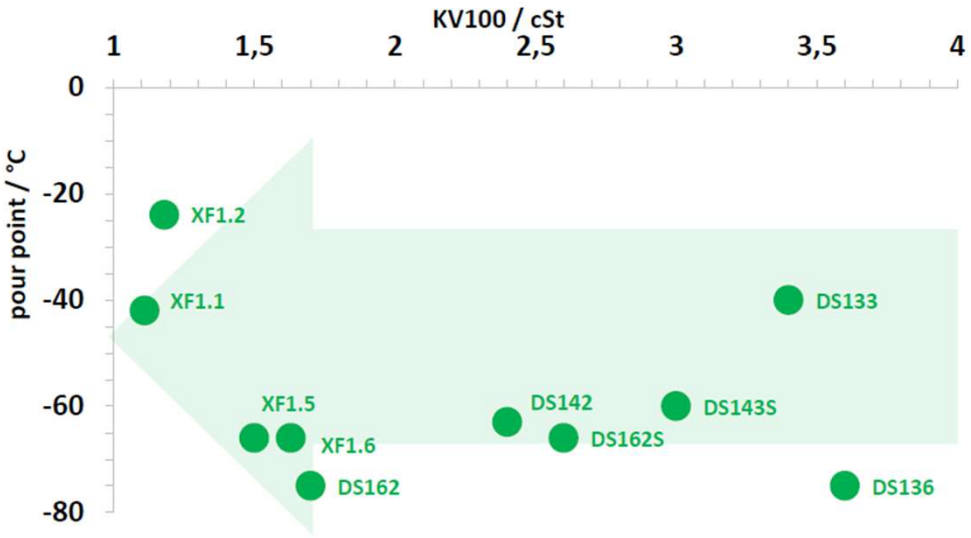
- High material compatibility
  - Low reactivity with Cu, Al, Ag
  - Elastomers and plastics
- Low viscosity (≤3 cSt)
  - Cooling capacity increases as viscosity drops
- High cooling efficiency
  - High thermal conductivity and specific heat
- Commercially available in large quantities

Ultra low viscosity PAO - PAO's fit for thermal management and EV driveline

Property	Dielectric cooling fluid for battery/ e-motor/electronics and datacenters			Dielectric cooling fluid / (EV-)driveline fluid	(EV-)driveline fluid / low viscous engine oils	
100°C Viscosity (cSt)	1.7	2.6	2.4	3.0	3.4	3.6
40°C Viscosity (cSt)	5.1	9.4	8.6	11.7	13.2	14.6
-40°C Viscosity (cSt)	275	947	711	1306	<2000	1714
Viscosity Index		109	95	111	136	133
Flash Point (°C)	160	173	193	197	218	226
Pour Point (°C)	-75	-75	-63	-60	-40	-75
Noack Volatility @200°C (%wt loss)	33.0	21.0	8.3	6.7	2.5	1.2

- New development direction is to produce ultra-LV PAO maintaining their important features such as low pour point and low viscosity at low temperature. The challenge is to keep Noack volatility low even with low viscosities. DS142 is a successful example.

Ultra low viscosity PAO - New Developments for Extreme LV PAO

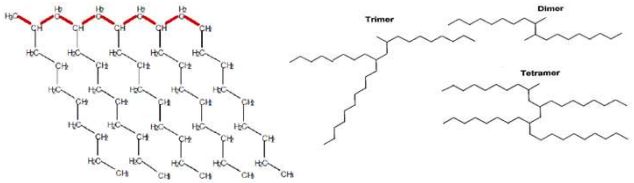


Property	XF1.1	XF1.2	XF1.5	XF1.6
100°C Viscosity (cSt)	1.11	1.18	1.50	1.63
40°C Viscosity (cSt)	2.52	2.84	4.52	4.98
Flash Point (°C)	129	128	129	140
Pour Point (°C)	-42	-24	<-66	-66

- Market trend is to further lower the viscosity of EV fluids, gear oils, industrial oils or engine oils to reduce powertrain losses and further improve efficiency of EVs as part of measures toward achieving carbon neutrality.
- One effective method is to reduce lubricating oils viscosity.
- New developments of INEOS Oligomers focus on further lowering PAO viscosity.
- These extreme LV PAOs can be good candidates for future functional fluids in gear box, clutch, transmission oil formulations, aerospace greases, or as coolants for electric motors, data centers, and battery packs.

High viscosity mPAO - Product range and new developments

- HV PAOs are synthetic oligomers made by oligomerization of LAO (primarily 1-decene) with acid/metallocene catalyst
- Resulting mixture contains pentamer and higher oligomers → hydrogenation → fractionation
- Comb like structure (mPAO vs. conventional)



PAO GRADE:	50	65	100	150	170
100°C Viscosity (cSt)	50.3	65.0	98.0	135.0	170
40°C Viscosity (cSt)	411	555	927	1250	1627
Viscosity Index	186	189	197	216	225
Flash Point COC (°C)	286	280	290	290	274
Pour Point (°C)	-47	-45	-40	-37	-39

- **Improvements over conventional**
  - Higher Viscosity Index
  - Low Temperature Properties (viscosity at low temp., pour point, …)
  - Better Shear Stability
  - Lower Foaming
  - Better demulsibility

- **High viscosity properties that stand out**
  - Improved Oxidative Stability (less tertiary C-atoms)
  - Enhanced Film Thickness

High viscosity mPAO- Use in Automotive Gear oils

- Viscosities - Formulation examples:

	mPAO	Conventional PAO 100	mPAO	Conventional PAO 100
Targeted Viscosity Grade	75W-110	75W-110	75W-140	75W-140
Additive Package	9	9	9	9
PAO 4	26	29	18	20
Di-(Tridecyl) Adipate	15	15	15	15
mPAO	**50**	---	**58**	---
Conventional PAO100	---	**47**	---	**56**
Viscosity at 100°C (cSt)	20.5	20.2	26.4	26.9
Viscosity at 40°C (cSt)	130.1	146.6	177.7	214.9
Viscosity Index	182	160	184	160
Brookfield Visc. @ - 40°C (mPa/s)	65,069	103,658	101,298	225,052

➢ Formulation with mPAO result in higher VI and lower viscosity at low temperature than with cPAO.

High viscosity mPAO - Use in Automotive Gear oils

- Oxidation stability:

75W-140 Formulation	mPAO Gear Oil	Reference Gear Oil
L-60 Oxidation Test (50 Hr)		
Viscosity Increase - 100% Max.	5%	35%
Sludge Merits - 9.4 Min	9.5	9.2
Carbon Varnish Merits - 7.5 Min.	8.2	9.2
Pentane Insolubles – 3% Max..	0.3	2.0
Toluene Insolubles – 2% Max.	0.3	0.6

➢ Formulation with mPAO result in lower viscosity increase, varnish and insoluble than with cPAO.

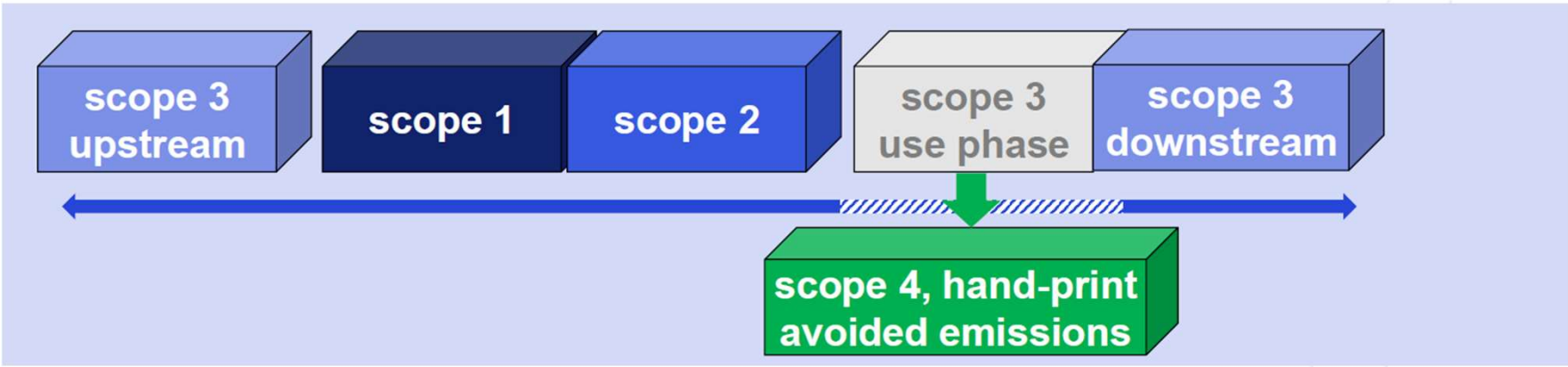
- Shear stability (KRL tapered roller bearing 20h test):

	mPAO	Conventional PAO100
KV @100°C (mm^2/s): Before	102.0	102.1
KV @100°C (mm^2/s): After	100.6	99.65
Change (%)	1.4	2.4
Viscosity Index: Before	203	169
Viscosity Index: After	203	168

➢ Formulation with mPAO result in lower viscosity change than with cPAO.

Sustainability - Sustainability roadmap: PCF Product Carbon Footprint

- Sustainability with PAOs:



Example with long-life PAO engine oil formulation from Fluitec:

➢ Although the product footprint of PAO is higher than mineral oil base stocks, PAO contributes to sustainability.

Sustainability - Sustainability roadmap: PCF Product Carbon Footprint

- Roadmap for reducing carbon emissions:

Scopes	Emission factors	Ineos on-going improvement actions
Scope 1	- fuels - flare	**- bio-fuel, hydrogen, etc.** **- process optimization**
Scope 2	- electricity - steam	**- nuclear, solar (Feluy), or wind energy** **- process optimization (reduced energy needs)**
Scope 3 Upstream	**- feedstock (raw materials)** - waste generation - feedstock transport	**- 1) PCF improvement of our suppliers** **2) mass-balance: ISCC+ certification** **3) *(bio-based feedstock)*** **- optimization of process** **- selection of transport**
Scope 3 Downstream	**- end of life** - product transportation	**- recycling (25%)** **- regional supplier**
Scope 3 Use phase	- emissions from customer / consumer	**- optimization** **- avoiding emissions: scope 4**

Sustainability - ISCC+ International Sustainability and Carbon Certification Plus

- What is ISCC+ Certification?
  - Well recognized global standard
  - Credible certification solutions for circular and bio-based feeds, enabling companies to make credible claims
  - One-stop-shop to address sustainability requirements
  - Provides the verification of sustainability, chain of custody, attribution rules, and full traceability along the supply chain

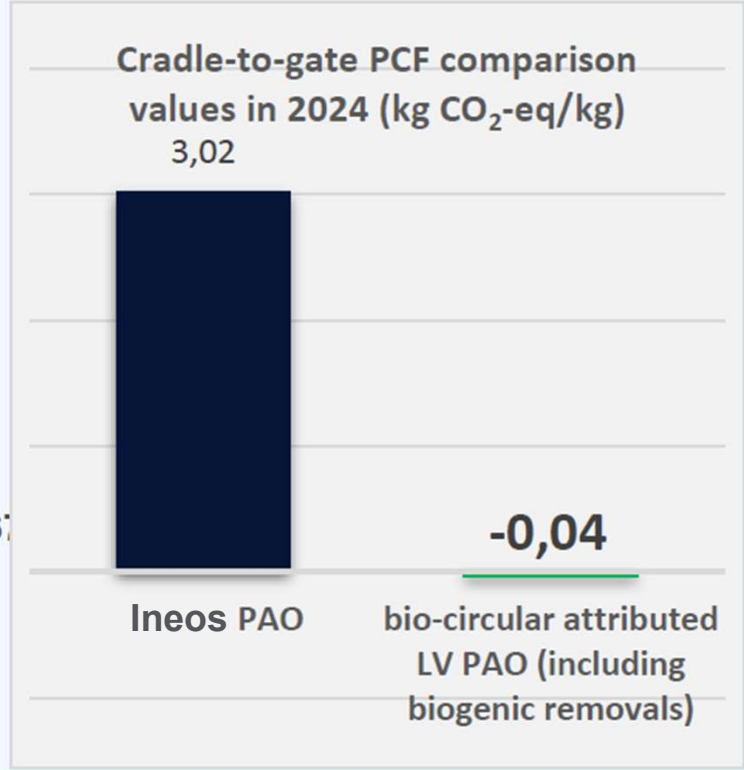
- Ineos bio-circular LV PAOs
  - Replaces fossil feedstock with 100% certified bio-circular raw materials via a mass balance approach.
  - Demonstrated at commercial scale in integrated plants in Cologne, Germany. Investigating possibilities in the US.
  - Does not compete with food production, is converted into bio-circular ethylene which in its turn is converted to LAO and PAO in our Feluy (Belgium) facility.
  - Amount of bio-circular based feedstock is attributed to the end product using the mass balance method fully certified by ISCC+ to track renewable materials and provide a more sustainable value chain.

Sustainability - ISCC+ International Sustainability and Carbon Certification Plus

Quality, Performance and Sustainability

Our certified mass balance approach includes several benefits

- ✓ **100% substitution** of fossil by sustainable feedstocks
- ✓ **Drop-in solution:** Same product, same performance.
- ✓ **Significant CO_2 emission reduction according to ISO1406**
- ✓ **Positive environmental and socioeconomic impact**
- ✓ **Certified traceability**



Conclusion

- Both LV and HV PAO meet the requirements of current and future needs for Automotive lubricants (fuel economy, better LT viscosity, shear stability, oxidation)
- LV PAO is a key raw material for immersion cooling fluids formulation (cooling efficiency, material compatibility)
- Ineos engaged towards Sustainability:
  - Engine oil formulation based on PAO has lower cradle-to-gate PCF vs. mineral oil based formulation.
  - ISCC+ certification for Ineos PAOs.

IMCD

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Thank you!

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