F+L WEEK

Base Stock Logistics
as we Move to a Low Viscosity Engine Oil World

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NESTE

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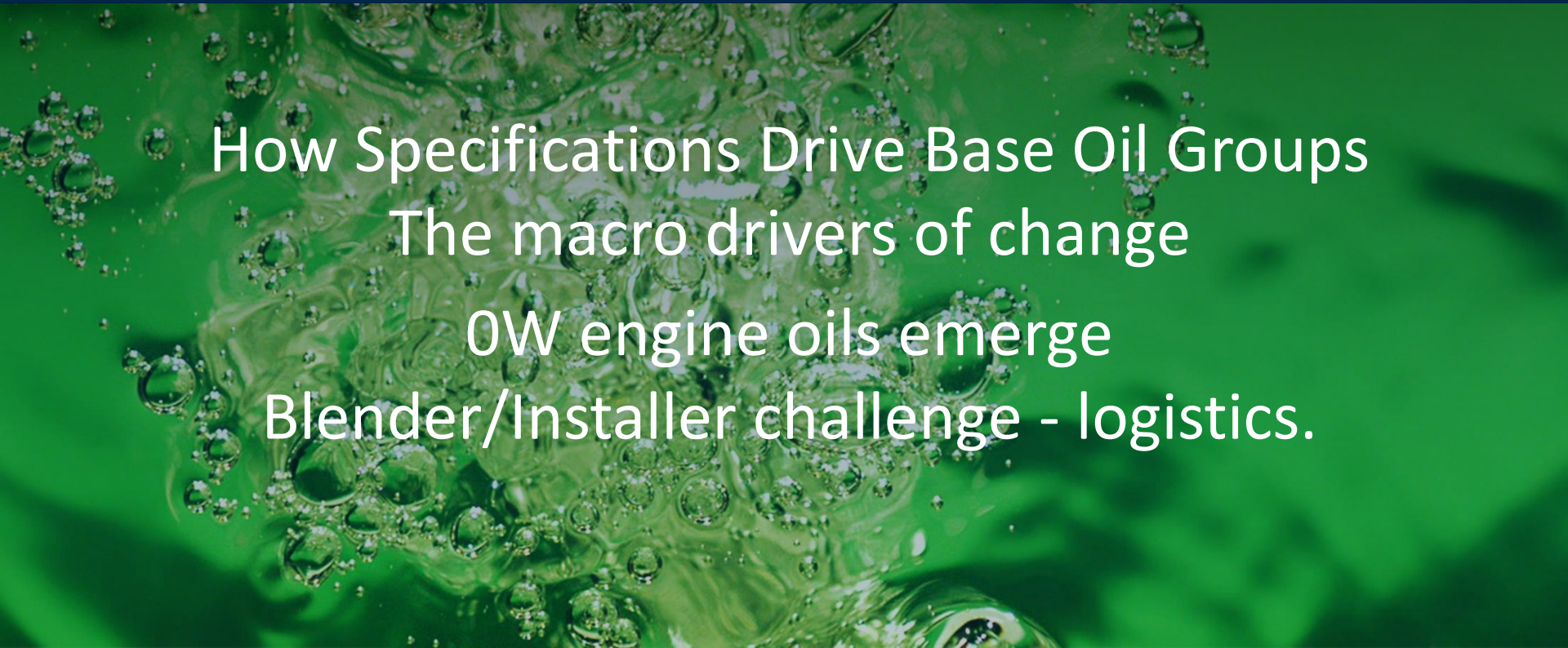
Overview



How Specifications Drive Base Oil Groups

The macro drivers of change

0W engine oils emerge

Blender/Installer challenge - logistics.

How Specifications Drive Base Oil Groups

No finished oil specification
ever mentions Base Oil Group
but the performance spec sets the minimum.

Four base stock properties key to specifications

High Temperature High Shear Viscosity (HTHS)

Kinematic Viscosity (KV)

Cold Crank Simulator Performance (CCS)

Volatility (Noack)

SAE J300 PCMO Viscosity Grades

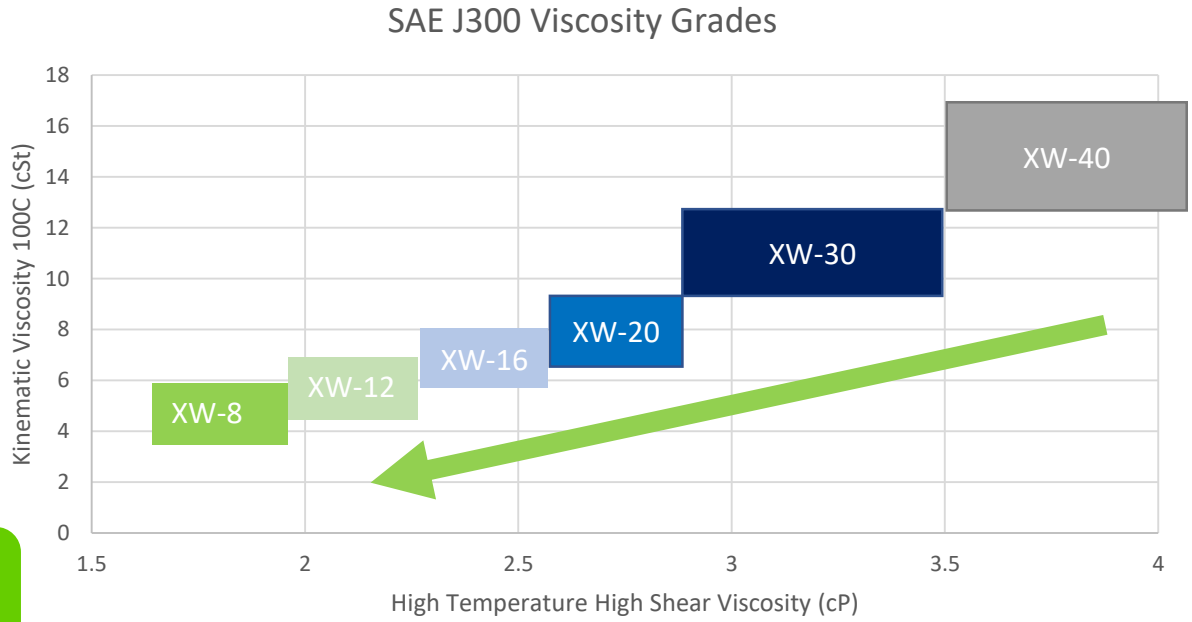
High Temp High Shear viscosity

Less Drag ⬇ HTHS ⬆ Wear Protection

SAE Grades tied to specific HTHS ➡ Fuel Economy

SAE J300 PCMO Viscosity Grades

The move to lower HTHS & better fuel economy has been very aggressive



5W-30 is dominant globally but lower grades are growing

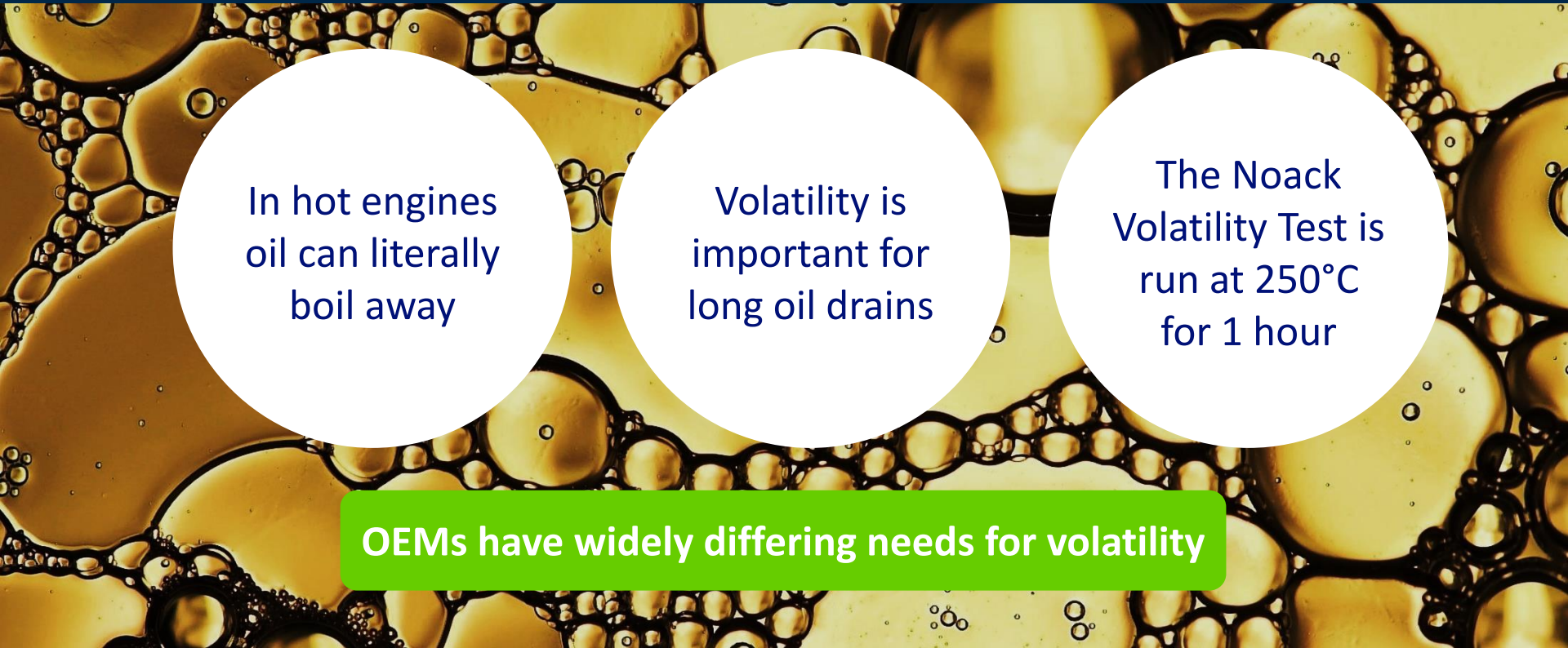
SAE J300 Winter Viscosity Grades

- Multi-grade oils flow more freely at low temperature setting the SAE Winter Grade
- Cold crank simulator (1964) mimics the ability of a starter system to “crank” a cold engine sump
- CCS test temperature changes with SAE Winter Grade:

  -35°C for 0W, -30°C for 5W, -25°C for 10W

Pour Point Depressants ensure the oil flows after start-up

OEMs Dictate Maximum Volatility



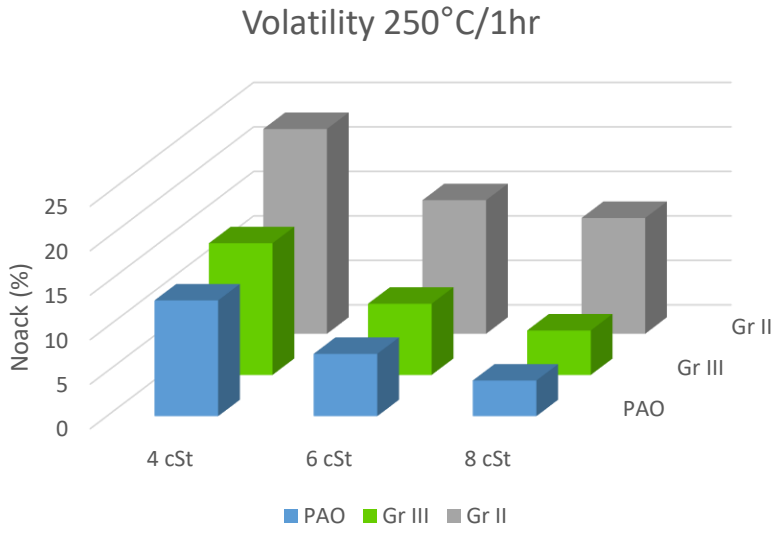
In hot engines oil can literally boil away

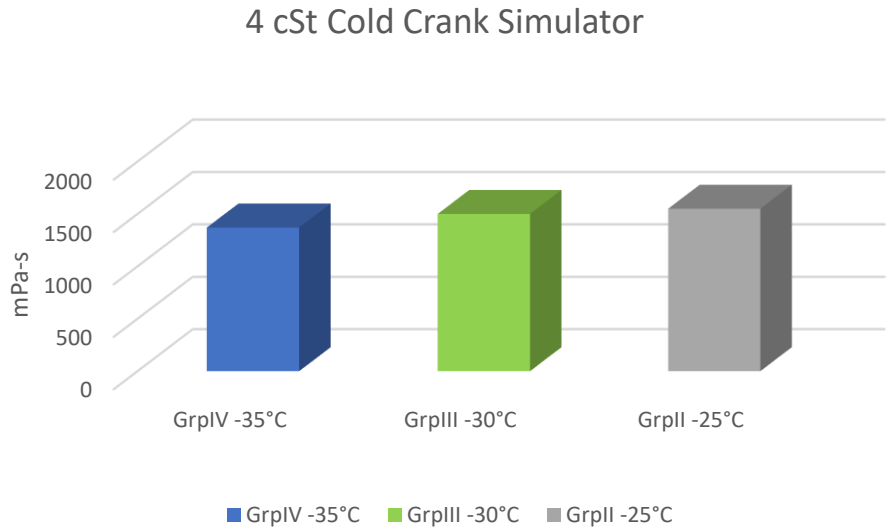
Volatility is important for long oil drains

The Noack Volatility Test is run at 250°C for 1 hour

OEMs have widely differing needs for volatility

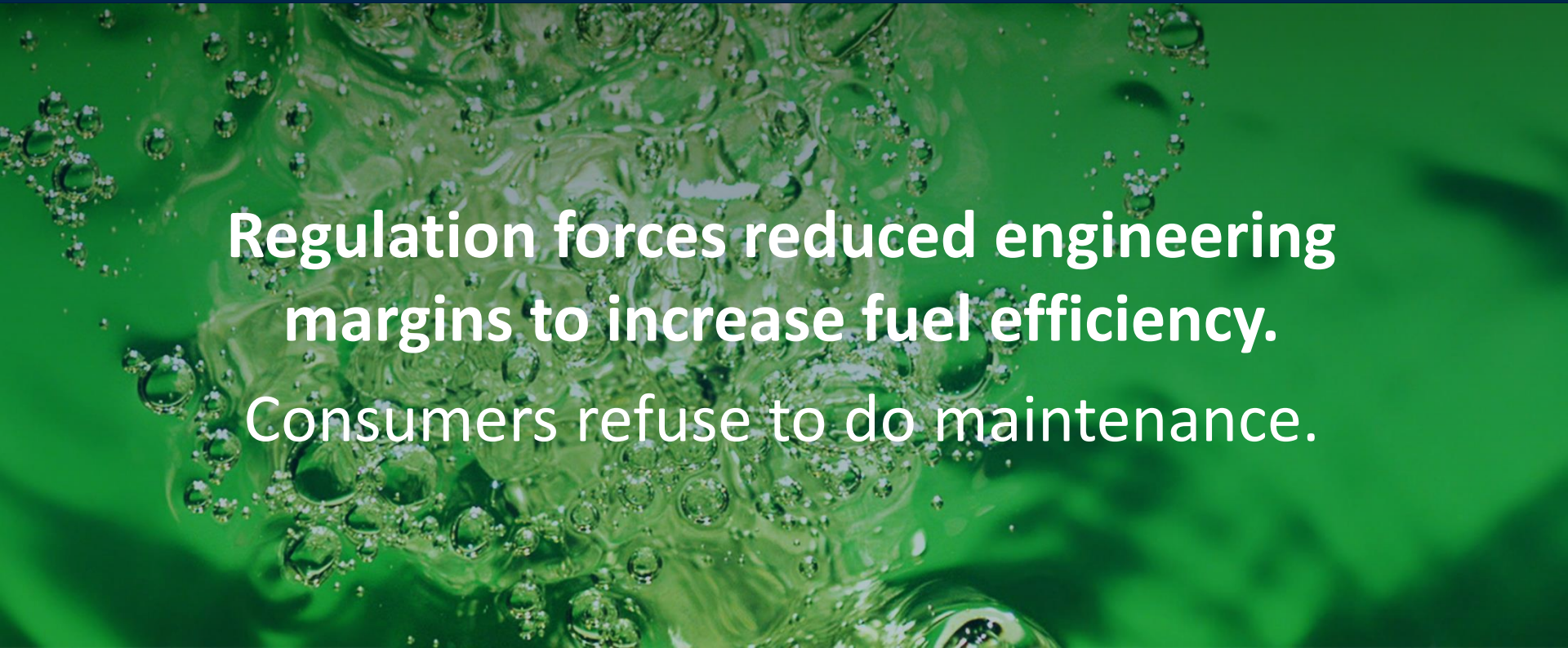
Balancing CCS & Volatility → Base Oil Selection





Meeting low volatility requirements & extremely low temperature CCS targets drives high API Groups

The macro drivers of change



Regulation forces reduced engineering margins to increase fuel efficiency.

Consumers refuse to do maintenance.

Customer behavior, liabilities & costs → OEM spec

Consumer poor service habits demand long drain

- Low volatility & excellent thermal & oxidative stability

Warranty costs are critical

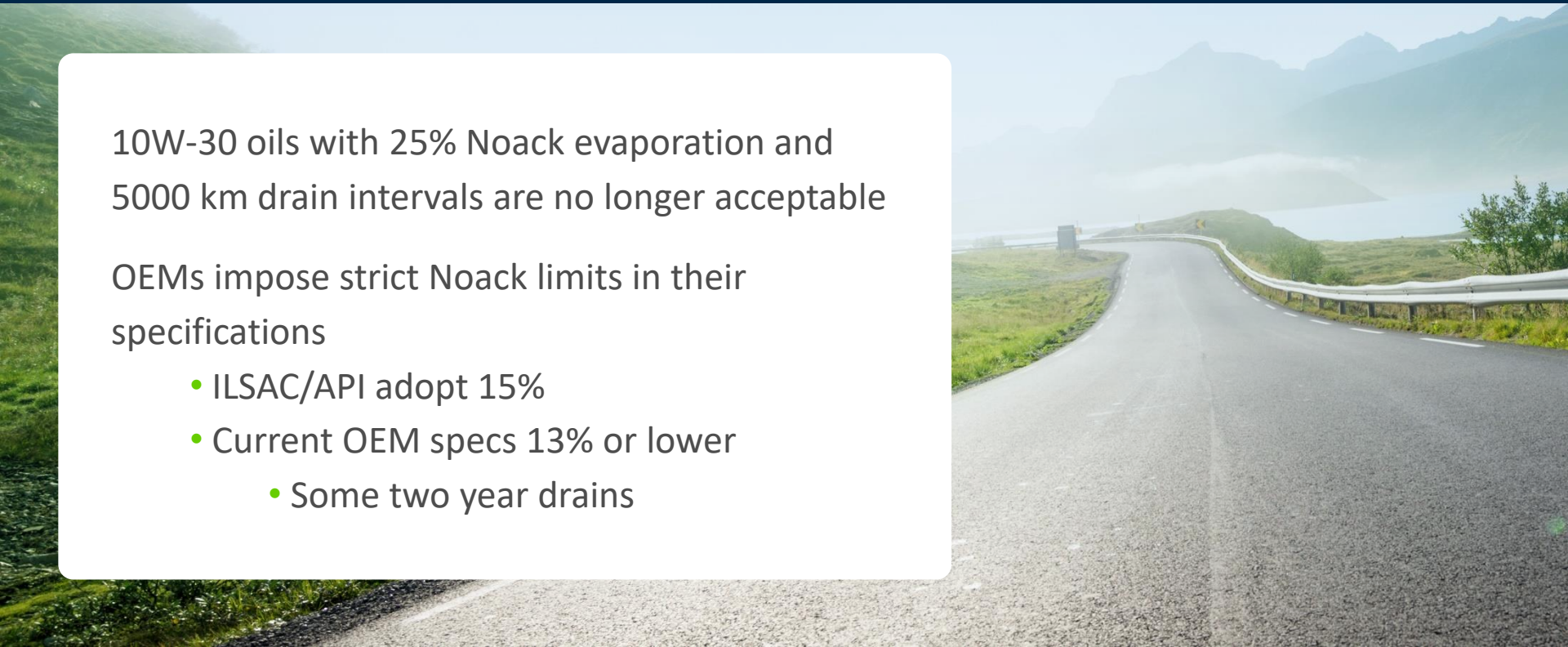
- Durability recommends high HTHS viscosity

Regulatory fines for fuel inefficiency are devastating

- Reduce HTHS viscosity

Low volatility, low HTHS oils with reengineered engines enable minimum warranty, penalties and cost

Long Drain



10W-30 oils with 25% Noack evaporation and 5000 km drain intervals are no longer acceptable

OEMs impose strict Noack limits in their specifications

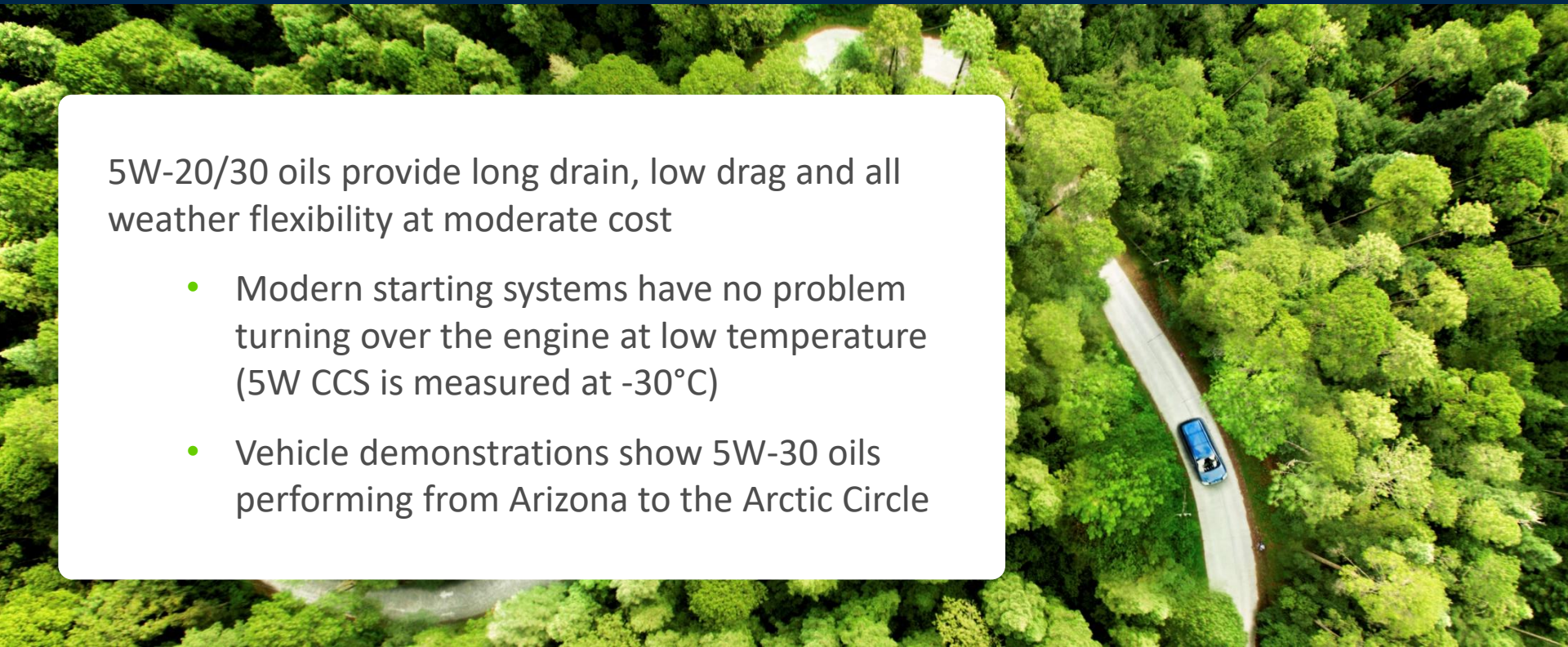
- ILSAC/API adopt 15%
- Current OEM specs 13% or lower
  - Some two year drains

Long Drain & Fuel Economy → 5W-30/20

- 2000-2010 sees 5W oils grow from 20% to 70% in North American PCMO
- ~2000 Japanese OEMs & Ford move to 5W-20
- Europe largely moves to 5W-30

Group III with some Group I/II becomes the cost effective formulating choice

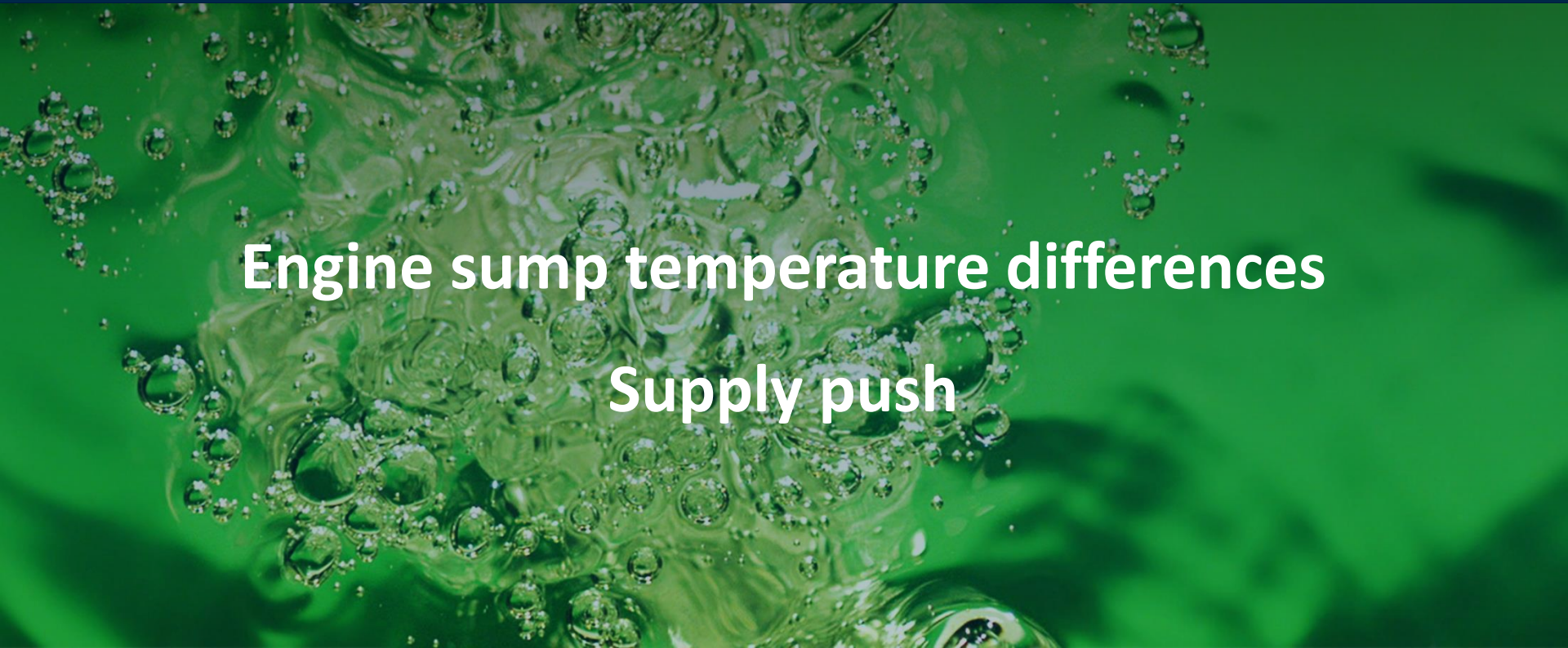
5W-20/30 Oils Hit the Sweet Spot



5W-20/30 oils provide long drain, low drag and all weather flexibility at moderate cost

- Modern starting systems have no problem turning over the engine at low temperature (5W CCS is measured at -30°C)
- Vehicle demonstrations show 5W-30 oils performing from Arizona to the Arctic Circle

0W engine oils emerge



Engine sump temperature differences

Supply push

Seeking Improvement/Leveraging Differences

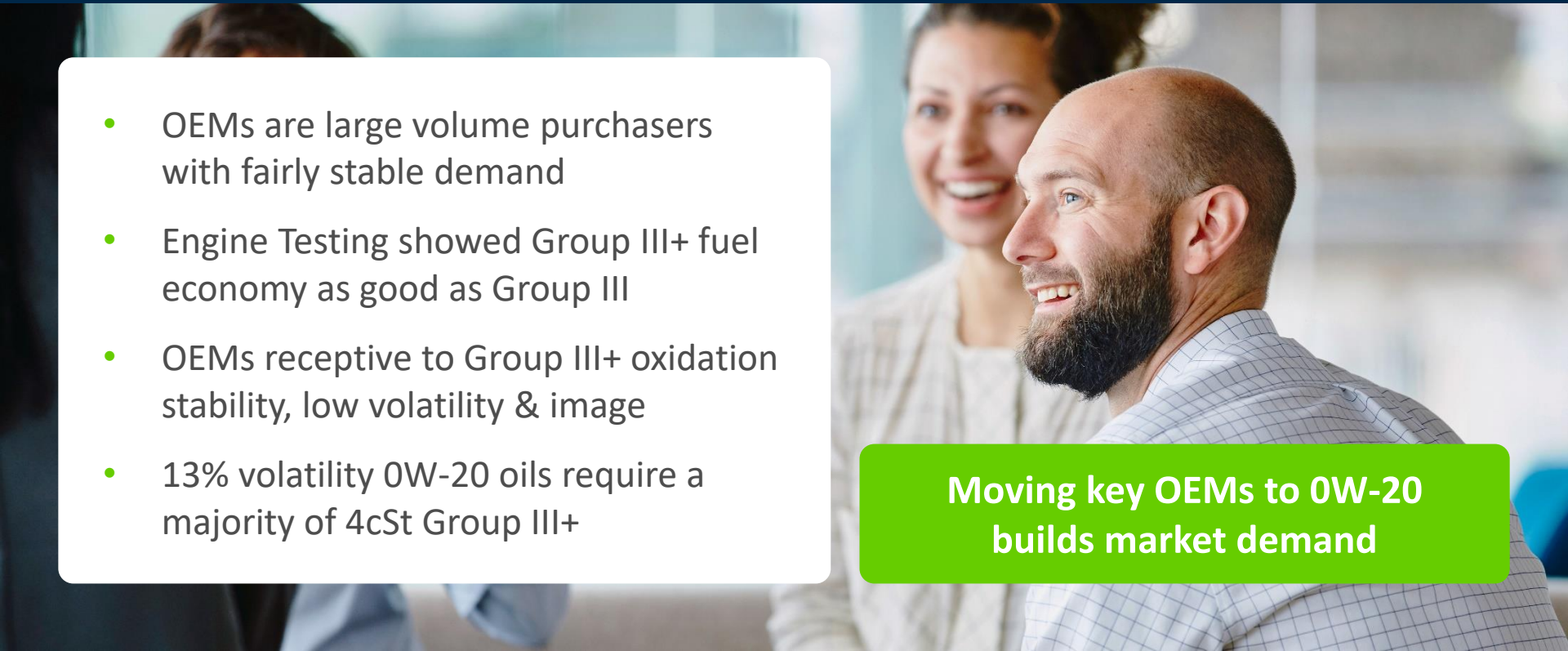
- EU/NA engines typically operate ~100°C sump temperature
- Many Japanese engines run cooler ~80°C
- At 80°C some motored tests show a small fuel economy improvements for 0W-20 compared to 5W-20 oils
- 0W-20 launched in Japanese vehicles around 2010

Standard Group III can make 0W-20 oils at 15% Volatility

New Group III+ Supply

- In 2012 a 1MM MT/yr plant came on line in the Middle East
- Placing this large capacity in the market was a major challenge
  - High quality
  - Group III+ not necessary for 5W-20/30

Create Demand: Factory Fill → Service Fill

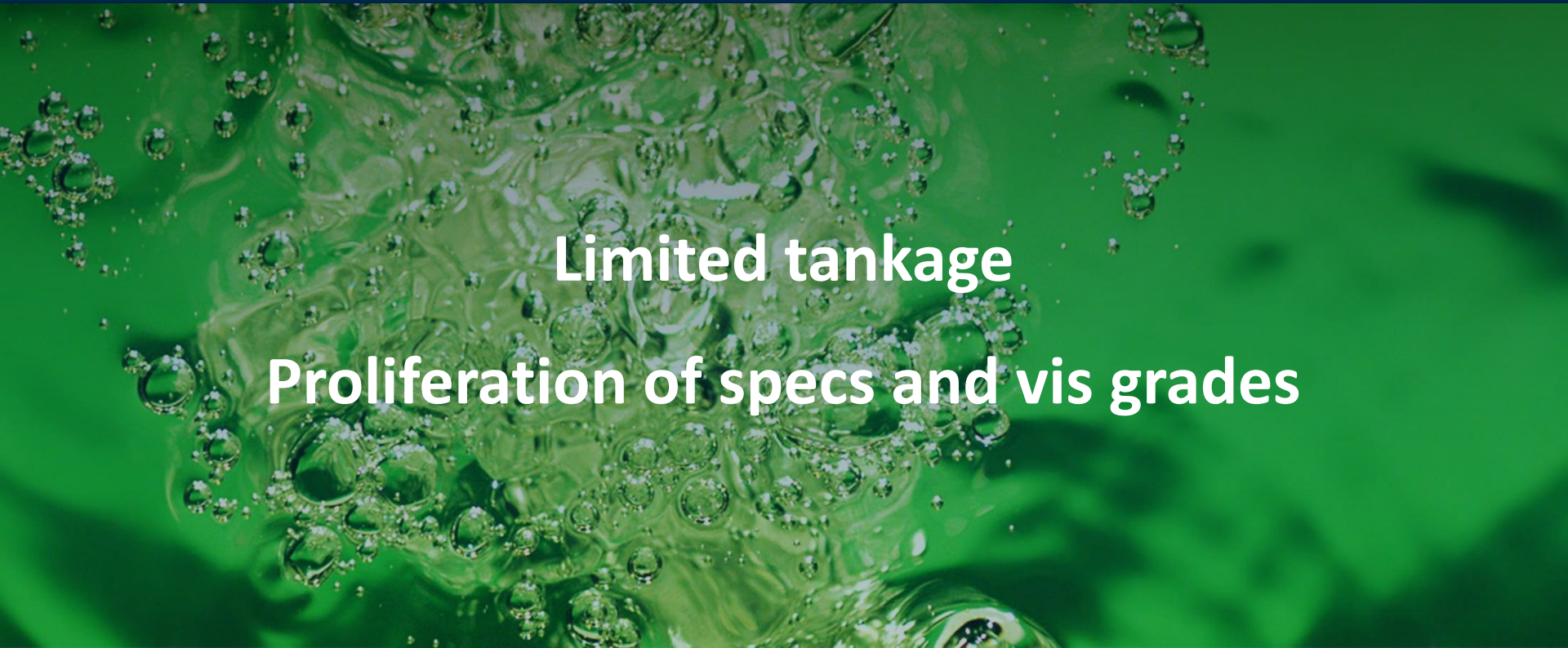


- OEMs are large volume purchasers with fairly stable demand
- Engine Testing showed Group III+ fuel economy as good as Group III
- OEMs receptive to Group III+ oxidation stability, low volatility & image
- 13% volatility 0W-20 oils require a majority of 4cSt Group III+

Moving key OEMs to 0W-20 builds market demand

OEMs recommending some 0W

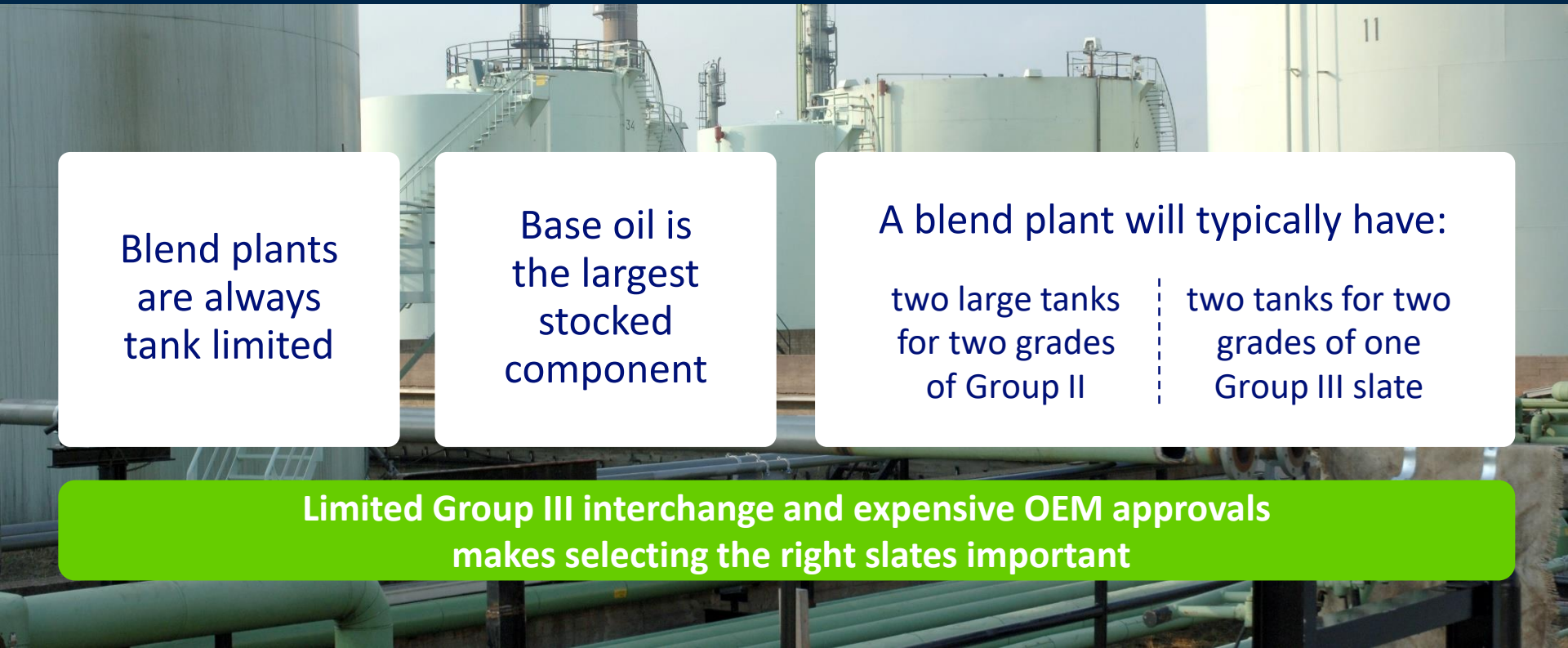
Blenders/Installers challenge - Logistics



Limited tankage

Proliferation of specs and vis grades

The Blender's Challenge - Tankage



Blend plants are always tank limited

Base oil is the largest stocked component

A blend plant will typically have:

- two large tanks for two grades of Group II
- two tanks for two grades of one Group III slate

Limited Group III interchange and expensive OEM approvals makes selecting the right slates important

Low Volatility 0W-XX oils in the blend plant?

- dexos™1 in the US provides some insights
  - Add tankage
  - Shift single plants to Group III+
  - Toll blend specialty oils
- North American market uniquely uniform specifications (~80% API only)

Multiple low volatility OEM 0W oils very difficult

- Dominant 5W oils don’t need Group III+
- Commercially available Group III+ slates are limited
- OEM approvals very expensive and take time
  - Toll blending & dedicated plant solutions needed

Service Fill Installer Challenge - Complexity

- Dealerships often conduct installations while the vehicle is under warranty
- EU OEMs frequently provide multiple service fill oil recommendations
  - Simplicity and cost savings
  - Consumers prefer cheaper and readily available 5W-20/30 to 0W-20

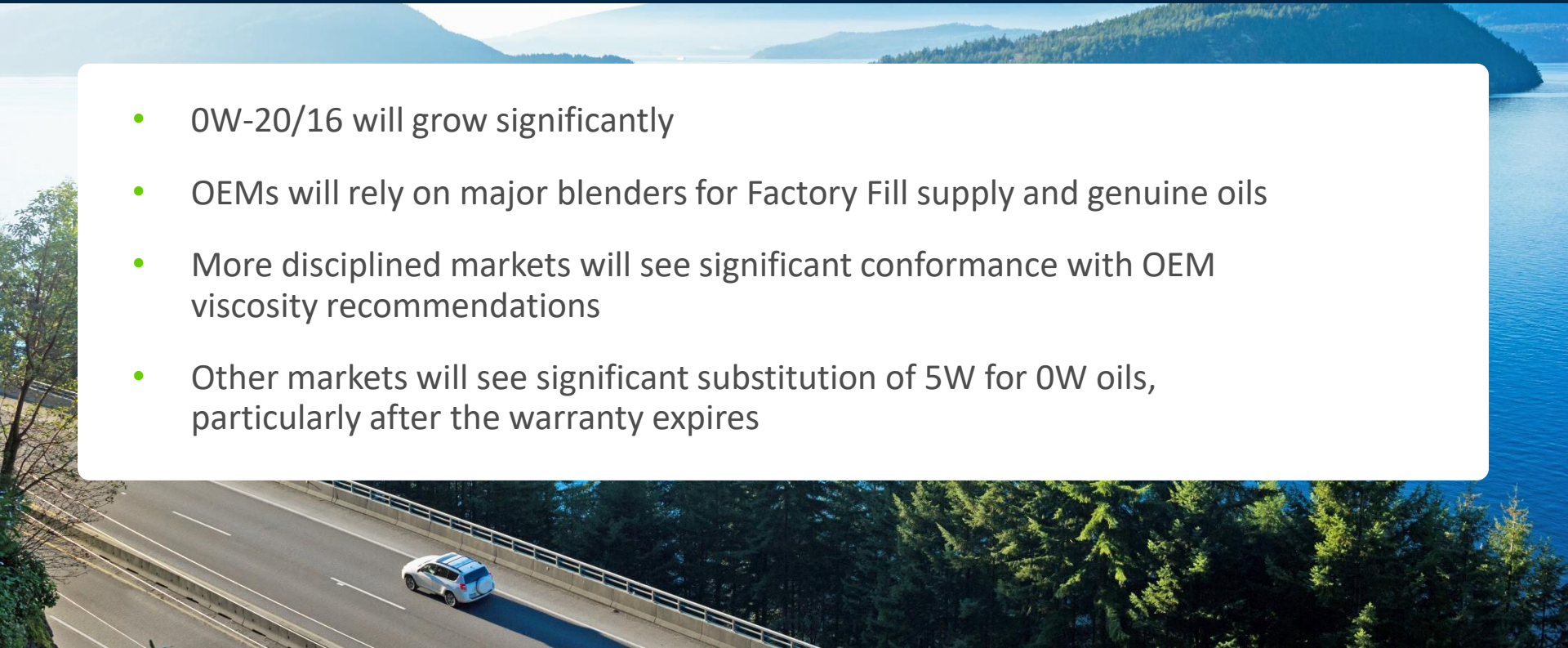
Predicting Group III to 2025 – North America

- 0W-20/16 oils will become an increasing part of the FF & SF market in the USA
  - 5W-30/20 dominant
  - 0W-20 serviced with standard Group III
- Consumers follow the recommended viscosity grade
- The premium for 0W-20 low volatility oils is low

Group III+ will be an important part of meeting low volatility specifications using plant segregation & toll blending

Predicting Group III to 2025 – EU and ROW

- 0W-20/16 will grow significantly
- OEMs will rely on major blenders for Factory Fill supply and genuine oils
- More disciplined markets will see significant conformance with OEM viscosity recommendations
- Other markets will see significant substitution of 5W for 0W oils, particularly after the warranty expires



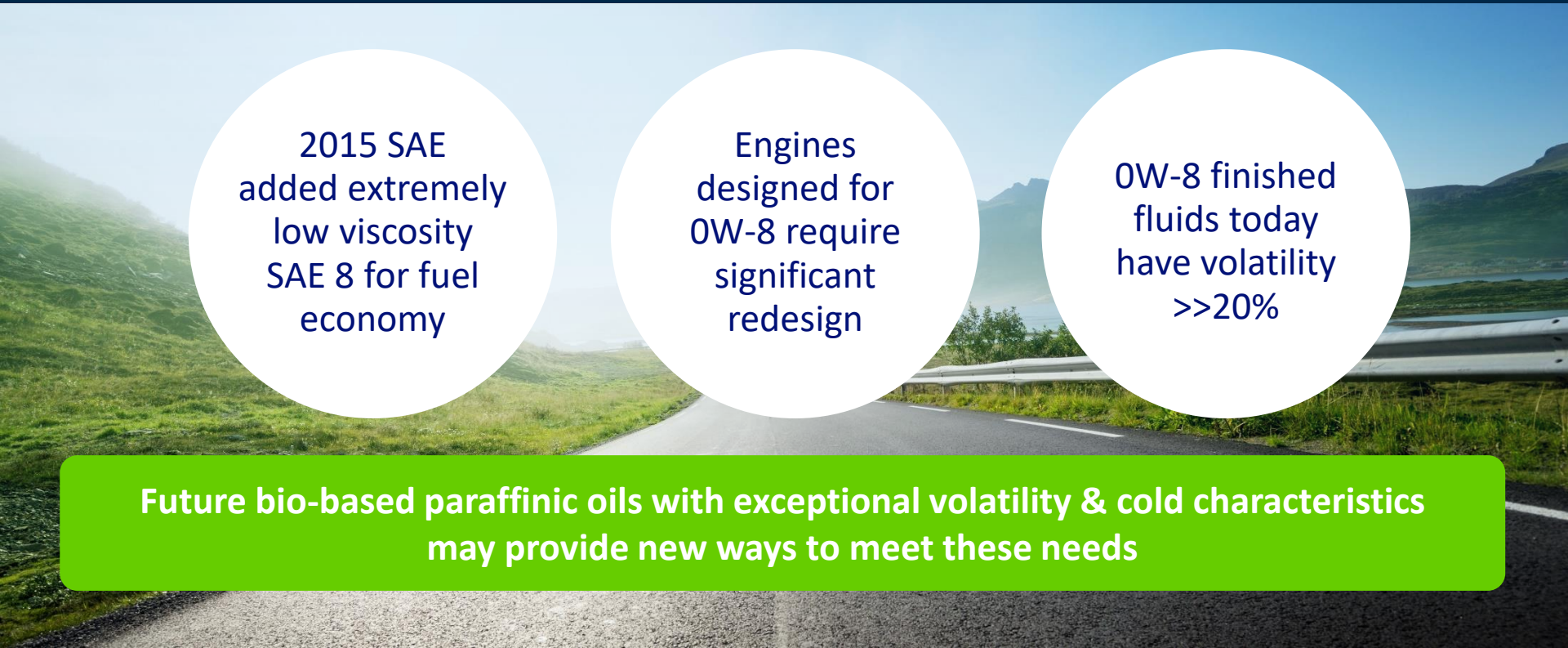
Summary: Low Viscosity Logistics

Standard Group III will satisfy 15% volatility 5W & 0W demand

Proliferation of specifications & viscosity grades is very difficult for installers & blenders

Consumers & installers are likely to select 5W-20/30 oils outside warranty

Next Generation 0W-8/12 oils

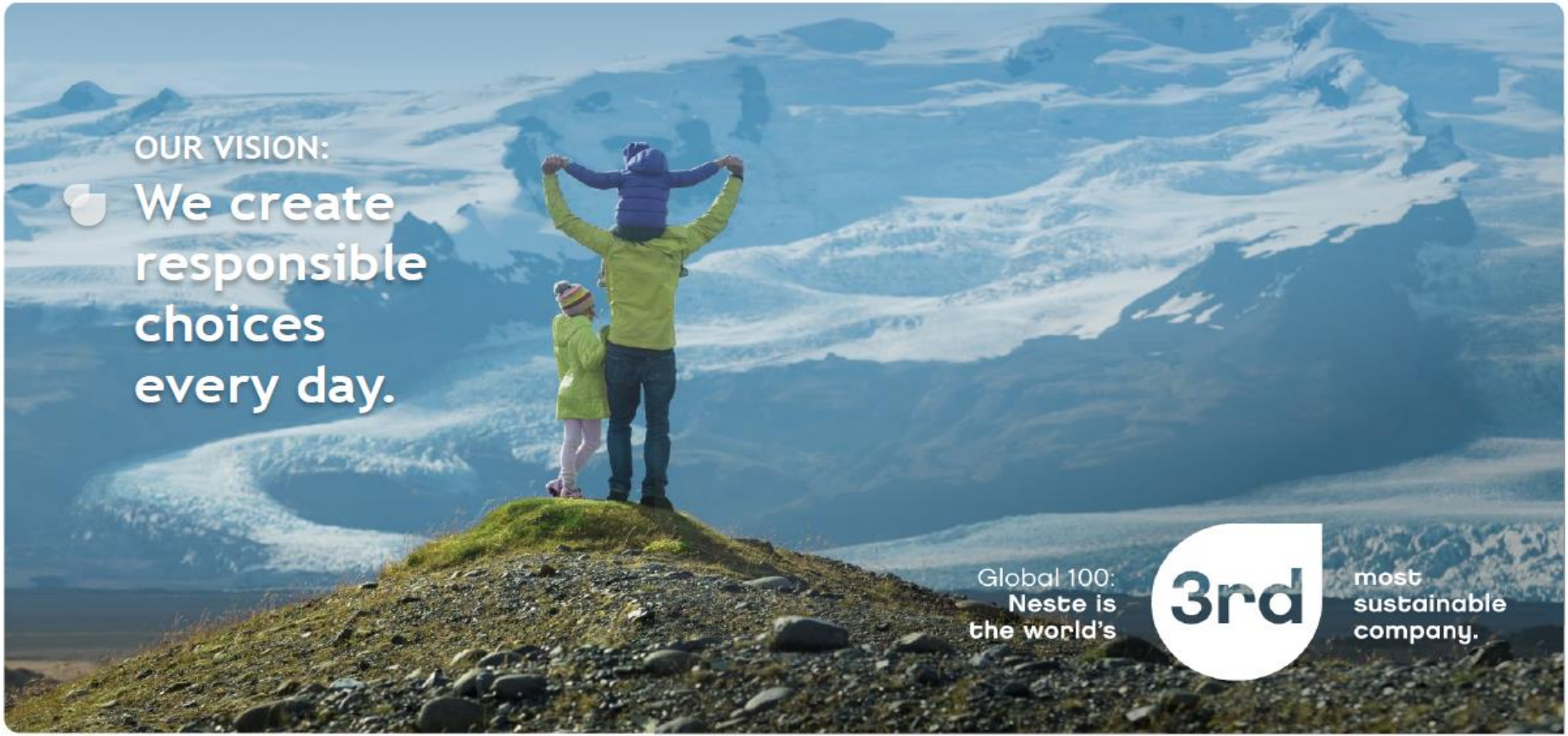


2015 SAE added extremely low viscosity SAE 8 for fuel economy

Engines designed for 0W-8 require significant redesign

0W-8 finished fluids today have volatility >>20%

Future bio-based paraffinic oils with exceptional volatility & cold characteristics may provide new ways to meet these needs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