Automotive Trends

Global PVL Market Trends

Global CVL Market Trends

Lubricant Market Review
Global Market Trends

95.6 Million global light vehicle sales

VW Group 10.8 million

0.3–2.0% growth expected in 2019

Plug in sales up 72% on 2017

No1. Toyota Corolla >1.1 million
  • Sold in 150 countries and regions
Top-Selling Vehicles Around the World in 2018

**US:** F-150 - 909,330

**Europe:** VW Golf - 502,752

**Japan:**
- Micro car: Honda N-Box - 241,870
- Standard: Nissan Note - 136,324

**Russia:**
- Lada Vesta - 108,364

**China:**
- Sedan: VW Lavida - 503,800
- SUV: Haval H6 - 452,600

Ford F-150 retains the US top spot

Image: Ford Motor Company
# 2018 Snapshots of the 4 Biggest Markets

<table>
<thead>
<tr>
<th>CHINA</th>
<th>U.S.</th>
<th>EUROPE</th>
<th>JAPAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Decline 4.1%</td>
<td>- Slow growth 0.6%</td>
<td>- Almost flat +0.1%</td>
<td>- Almost flat +0.1%</td>
</tr>
<tr>
<td>- Sales &gt;23 million</td>
<td>- Sales &gt;17 million</td>
<td>- &gt;15 m. registrations</td>
<td>- Sales &gt;4.3 million</td>
</tr>
<tr>
<td>- VW No1: 4.1 m.</td>
<td>- Ford No1: 2.46 m.</td>
<td>- VW No1: 3.7 m.</td>
<td>- Toyota &gt;30% of the market</td>
</tr>
<tr>
<td>- Strong position for local OEMs in SUV market</td>
<td>- Top 3 models all Pickups</td>
<td>- Big gains: PSA Grp +32%, Jeep + 55%</td>
<td>- Top 4 sellers are Micro-cars</td>
</tr>
<tr>
<td>- Gain for Geely +20% - 1.5 million</td>
<td>- Biggest gains for Jeep +17.5% &amp; Ram +7.3%</td>
<td>- Diesel share down to 35% from 43%</td>
<td>- Top 3 models all hybrids</td>
</tr>
<tr>
<td>- BYD tops NEV &gt;247,000 sales</td>
<td>- Tesla enters top 20~190,000 sales</td>
<td>- 2.1% cars can be electrically charged</td>
<td>- &gt;1 million hybrid sales &gt;26% sales</td>
</tr>
</tbody>
</table>
**2018 Snapshots of 4 Growth Markets**

<table>
<thead>
<tr>
<th>Country</th>
<th>Growth</th>
<th>Sales</th>
<th>Top Brands</th>
<th>Fuel Efficiency</th>
<th>Hybrid/Electric</th>
<th>Imports</th>
<th>Sales Volume</th>
<th>Top Brands</th>
<th>EV Sales</th>
<th>Charging</th>
<th>Tesla Launch</th>
<th>Demand</th>
<th>Sales Increase</th>
<th>Top Brands</th>
<th>Market Share</th>
<th>EV Sales</th>
<th>Charging</th>
<th>Tesla Launch</th>
<th>Sales Increase</th>
<th>Sales Volume</th>
<th>Top Brands</th>
<th>EV Sales</th>
<th>Charging</th>
<th>Tesla Launch</th>
<th>Sales Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INDIA</strong></td>
<td>5%</td>
<td>~3.4 m</td>
<td>GM, VW, Fiat</td>
<td>Flex fuel</td>
<td>Domestic</td>
<td>Import</td>
<td>~2.5 m</td>
<td>GM, VW, Fiat</td>
<td>&gt;87%</td>
<td>2019</td>
<td>ROTA 2030</td>
<td>1.1%</td>
<td>12.8%</td>
<td>Lada, Kia, Hyundai</td>
<td>1.8 m</td>
<td>&gt;42%</td>
<td>2019</td>
<td>3%</td>
<td>82 EVs sold in 2017</td>
<td>12.8%</td>
<td>1.8 m</td>
<td>&gt;42%</td>
<td>2019</td>
<td>3%</td>
<td>82 EVs sold in 2017</td>
</tr>
</tbody>
</table>
Passenger Car Powertrain Trends

Powertrain mix continues to diversify

EV growth strong, but still <10% by 2025

Source: IHS Automotive, March 2019
Air Quality Improvements Through Legislation

China 6 – tightening emissions limits in 2020 and 2023

US Tier 3 emissions phasing in to 2025

Euro 6 gets tougher on PM, PN & Nox for diesel and gasoline

India jumps straight to Bharat VI

2016 Euro 5 implemented in Russia – no timeline for Euro 6

China 6b close to zero:
- NOx – 0.035 g/km
- PM – 0.0030 g/km
- PN – 6x10^11 #/km

Air Quality: Emissions reductions drive hardware innovation
CO$_2$ Reductions Targeted at Climate Change

US looks for 35% CO$_2$ reduction from light-duty
EU to cut CO$_2$ from cars by 30%
2020 could see 5 liter/100 km fleet average target in China
Japan to cut fuel consumption ~20% 2009-2020
India CAFE-style fuel economy norms tighten in 2022

Ultimate goal is “zero” emissions for road transport

Climate Change: OEMs are looking across the whole vehicle for solutions
Improvements in ICE Technology Continue

Mazda: SKYACTIVE-X Spark Controlled Compression Ignition
- 30% more torque, 20-30% better FE than current gasoline engine
- Available in 2019 in the Mazda3

Toyota Dynamic Force Engine
- 40% thermal efficiency, higher torque, fuel efficient

Daimler: New inline 6-cylinder petrol engine
- Launches in 2019 in S-Class

Nissan: Variable compression turbo
- Available in the 2019 Altima

GM: 2019 Silverado can run on 2-cylinders
ICE Innovations for Hybrids

INFINITI energy recovery system
• Instant electric torque & lag-free acceleration
• Scavenges & recycles heat and kinetic energy

EQ Boost EQ Power
• 48V system powers components & boosts engine improved efficiency and drivability
• Plug-in Hybrid with 50km electric only range

Mazda brings back the rotary engine
• Paired with battery as range extender
How will light-duty lubricant specifications for EMEA evolve?
ACEA LD Sequence Outlook

**2016**
- A3/B3
- A3/B4
- C3
- C4
- A5/B5
- C1
- C2
- C5

**2020**
- Legacy
  - 3.5 HTHS
  - A3/B4
  - C3
  - C4
- New
  - 3.5 HTHS
  - A3/B4
  - C3
  - C4
  - 2.9 HTHS
  - C2
  - C5

**Obsolete**
- A3/B3
- A5/B5
- C1

**New tests**
- Seq IVB, Fuel Economy

**New performance**
- LSPI, chain wear, turbo deposits + new tests

LD Sequence timing on track for mid/late 2020
ACEA LD Sequence Outlook

<table>
<thead>
<tr>
<th></th>
<th>A3/B3</th>
<th>A5/B5</th>
<th>C1</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>SAPS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HTHS</strong></td>
<td></td>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td><strong>Sludge</strong></td>
<td></td>
<td></td>
<td>M271 EVO</td>
<td></td>
</tr>
<tr>
<td><strong>VTW</strong></td>
<td></td>
<td></td>
<td>Seq. IVB (M271SL Grandfathering under discussion)</td>
<td></td>
</tr>
<tr>
<td><strong>FE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
<td></td>
<td>Seq. VH, DV6, EP6, VW TDI, OM646 wear, OM646 Bio</td>
<td></td>
</tr>
<tr>
<td><strong>Turbo deposits</strong></td>
<td></td>
<td></td>
<td>Not required</td>
<td>for continuing</td>
</tr>
<tr>
<td><strong>LSPI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chain wear</strong></td>
<td></td>
<td></td>
<td>categories</td>
<td></td>
</tr>
</tbody>
</table>

+ bench tests, viscosity and chemical limits carried over from ACEA-16

LD Sequence timing on track for mid/late 2020
# ACEA LD Sequence Outlook

<table>
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<tbody>
<tr>
<td>A3/B4</td>
<td>A7/B7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **SAPS**: Full
- **Application**: Gasoline and diesel
- **HTHS**: High
- **Sludge**: M271 EVO
- **VTW**: Seq. IVB (M271SL Grandfathering under discussion)
- **FE**: JASO FE (M111 FE Grandfathering under discussion)
- **Others**: Seq. VH, DV6, EP6, VW TDI, OM646 wear, OM646 Bio
- **Turbo deposits**: Not required for continuing categories
- **LSPI**: L-114
- **Chain wear**: Seq. IX

*LD Sequence timing on track for mid/late 2020*

+ bench tests, viscosity and chemical limits carried over from ACEA-16
# ACEA LD Sequence Outlook

## PASSENGER VEHICLES

### LD Sequence timing on track for mid/late 2020

<table>
<thead>
<tr>
<th>A3/B3</th>
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<tbody>
<tr>
<td>A3/B4</td>
<td>A7/B7</td>
<td>C2</td>
<td>C3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C4</td>
<td>C5</td>
</tr>
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<th>SAPS</th>
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<th>Others</th>
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<tr>
<td>Full</td>
<td>Gasoline and diesel</td>
<td>High</td>
<td>Reduced (Mid)</td>
<td>Seq. IVB (M271SL Grandfathering under discussion)</td>
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- Turbo deposits: Not required for continuing categories
- LSPI: Not required for continuing categories
- Chain wear: Seq. X

+ bench tests, viscosity and chemical limits carried over from ACEA-16
## ACEA LD Sequence Outlook

<table>
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<tr>
<td>Chain wear</td>
<td>Seq. X</td>
<td></td>
<td></td>
<td>Seq. X</td>
</tr>
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+ bench tests, viscosity and chemical limits carried over from ACEA-16

LD Sequence timing on track for mid/late 2020
COMMERCIAL VEHICLES

Global Trends

Global sales (Class 4-8) >3.3 million
Decline in demand expected in 2019
Alternative power vehicles +29%

Fuel costs and emissions legislation drive demand for greener vehicles
**Global Trends – Growth Markets**

**BRAZIL**
- Strong growth as economy recovers
- Bus & Heavy Truck Sales up 44%
- PROCONVE P8 (Euro VI) in 2022
- Growing ULSD B10 is B15 by 2023
- Extending Oil Drain Intervals

**RUSSIA**
- Economy up 2.3%
- Sanctions cost $6.3 billion
- CV sales up 2.7%
- KAMAZ 30% market share
- Euro V emissions
- Shift from GOST oil grades to API CI-4

**INDIA**
- Strong economic growth
- ~1 Million CV Sales up 27%
- Bharat Stage VI emissions in 2020
- Fuel economy tightens in 2021
- Potential for lubricant upgrade

**CHINA**
- Economy growth slowest in 30 years
- Production +1.7%
- CV Sales +5.1%
- Over 213K NEV CV sold, 80% BEV
- China VI phases in 2019-2023
- Oil Q-up expected
Global Trends – Emissions Regulations Drive Change

US. GHG Phase 2: MY 2021-2027
• Cut CO$_2$ emissions ~ 1.1 billion metric tons
• Save owners fuel costs of about $170 billion

Europe new proposals in May 2018
• 15% CO$_2$ reduction from 2019 levels by 2025
• 30% CO$_2$ reduction from 2019 levels by 2030

Euro VI equivalent emissions growing
• Wider use of EGR and SCR will prompt oil upgrades and lower SAPS formulations

Cleaner air and improved fuel economy are driving powertrain innovations at OEMs
Global Trends – Natural Gas for Transport

China - Most medium/heavy NGV growth

Russia – Ministry of Energy Program
- $2.6bn$ subsidies for gas producers, OEMs and regional authorities
- Target 700K gas vehicles and 1400 new gas stations by 2024

Europe - Volvo latest FH/FM LNG trucks
- Diesel pilot injection ignites gas
- Fuel consumption 15 - 25% lower than conventional Otto cycle gas engines

US - Cummins Westport ISX12N
- 400 hp / 1,450 lb-ft torque
- >1,000 produced since Feb. 2018
Global Trends – Modern NGV Lubrication

Latest mobile gas engine oils must deliver extra performance
• Cummins launches CES 20092 for improved oxidation and wear protection

Fleets with NGVs often have diesel and gasoline vehicles

Performance Heavy-Duty Gas Engine Oils
• CES 20092 requirements
• Oxidation/Nitration control
• Emulsion handling
• Fuel quality
• Extended drain protection

Performance Heavy-Duty Diesel Engine Oils
• Exceed CK-4 & OEM specs
• Oxidation control
• Soot handling capability
• TBN retention
• Extended drain protection

Performance Gasoline Engine Oils
• API SN requirements
• Catalyst compatibility

Multi-fuel lubricant options are increasingly attractive
Global Trends – ICE Continues to Improve

Turbo compounding – waste heat recovery
• Volvo – Improves FE by up to 6.5%

Uptake depends on fuel economy gains vs. various costs
Global Trends – Green Tech

Market Barriers Remain

Higher vehicle purchase price
Higher vehicle weight
Lack of recharging or refueling infrastructure
Battery service life and recycling
Poor ROI

Diesel Dominates Through 2040
How will heavy-duty lubricant specifications for EMEA evolve?
ACEA Update – Efficiency Improvements

Volvo T-13 and COAT tests may be added

New low viscosity F categories: HTHS from 2.9 to 3.2
- Two new tests for wear protection in low viscosity and low soot: CEC TDG-L-115 Bearing Wear and CEC TDG-L-116 Ring – Liner Wear

OM501 & OM646 test replacements

Tighter limits for some existing tests

Timing uncertain, but ACEA revisions may slip into 2020
Lubricant Trends

Lubricant Demand Drivers
Lower Viscosity Grades
Quality Upgrades
Globalisation of Oils
MARKET REVIEW

Emission Regulation is the Key Driver

**EU**
- **Emissions**: Euro IV/4, Euro V/5, Euro VI/6, Post-Euro VI/6
- **Test cycles**: ESC+ETC+ELR, WHSC+WHTC+WLTP
- **Monitoring of CO₂ emissions followed by mandatory limits**

**US-Federal**
- **Test cycles**: FTP transient cycles, FTP transient cycles + SET + NTE test
- **EPA 04**: EPA 07, EPA 10, EPA 10+Tier 3 (in line with California LEV III) for light-heavy duty
- **As from 2007+HD UDDS and HD-SFTP for light-heavy duty**

**China**
- **Test cycles**: China III, China IV, China V, China VI
- **CO₂ / CAFC**: ESC+ETC+ELR, ESC+ETC+ELR+WHTC
- **Phase 1**, **Phase 2**, **Phase 3**
- **Additional Ministry of Transport standards also apply**
MARKET REVIEW

Fuel Quality still varies globally

Maximum Sulfur Limits in Gasoline, 2019
Fiji implemented 50 ppm since January

Legend:
- 0-10 ppm
- 11-30 ppm
- 31-50 ppm
- 51-150 ppm
- 151-500 ppm
- 501-2,500 ppm
- No information / Not regulated

Countries may apply lower limits for different grades, regions/states, or based on average content. Detailed information on limits and regulations can be found at www.stratasadvisors.com
Source: Stratas Advisors, July 2019

Average sulphur levels in diesel in China

More than 91% of samples from China contained less than 10 ppm sulphur
So how does lubricant quality evolve across different regions
MARKET REVIEW

What Does the Fleet Look Like

Vehicle Type by Country
% of total fleet in that country

Source: Kline LubesNet
Total Vehicles: 453 Million
China 76%, Russia and Germany 12%

Vehicle Type by Country 2018
% relative total vehicle of combined
China, Russia & German Fleet

Source: Kline LubesNet
Total Vehicles: 453 Million

Germany | Russia | China
--- | --- | ---
Passenger vehicles | 53.8 | 80.2 | 83.7
Motorcycles, scooters, mopeds | | 22.7 | |
Light commercial vehicles | | | 15.8
Trucks | | | |
Off-highway vehicles/agriculture | | | |
Other commercial Vehicles | | | |

Total Vehicles: 453 Million

China 76%, Russia and Germany 12%
How does this play out in lubricant requirements?
Passenger Car Lubricant Demand Viscosity Grade Evolution
Passenger Car Lubricant Demand Viscosity Grade Evolution

VISCOSITY GRADE (%) RUSSIA 2017

VISCOSITY GRADE (%) GERMANY 2017

VISCOSITY GRADE (%) CHINA 2017
Lubricant Quality Upgrade

MARKET REVIEW

CHEMICAL LIMITS

- C3/C2/(C5)
  - SAE 5W-40/30
  - SAE0W-30

- C4/C1
  - SAE 5W-40/30

Renault JLR

MB229.52
MB229.51
MB229.31

MB
- SAE 0W-20/30

BMW
- SAE 0W-20/30

VW
- SAE 0W-20

JLR
- SAE 0W-20

PSA
- SAE 0W-20/30

FORD
- SAE 5W-20/30

FUEL ECONOMY
- HTHSV ≥ 2.6, 2.75, 2.9

NON CHEMICAL LIMITS

  - SAE 5W-40/30
  - SAE 0W-40/30

- A3/B3, A3/B4
  - SAE 5W-40/30

- A3/B3, A3/B4
  - SAE 10W-40

- A3/B3, A3/B4
  - SAE 15W-40

MB229.5

BMW LL-14FE+
- SAE 0W-20

MB 229.6
- SAE 5W-30

FORD
- SAE 5W-30

PSA
- SAE 0W-20/30

MB
- SAE 0W-20/30

BMW
- SAE 0W-20

VW
- SAE 0W-20

JLR
- SAE 0W-20

FORD
- SAE 5W-20/30

BMW
- SAE 0W-20

VW
- SAE 0W-20

FORD
- SAE 5W-20/30
MARKET REVIEW

Heavy Duty Diesel Lubricant Demand
Viscosity Grade Evolution

VISCOSITY GRADE % - RUSSIA 2027
VISCOSITY GRADE % - CHINA 2027
VISCOSITY GRADE % - GERMANY 2027
Heavy Duty Diesel Lubricant Demand
Viscosity Grade Evolution

MARKET REVIEW
MARKET REVIEW

Lubricant Quality Upgrade

CHEMICAL LIMITS

E6/E9/CK-4
Cummins 20083
VDS 4/4.5
SAE 10W-40

E6/E9/CJ-4
Cummins 20081
VDS 4/4.5
SAE 10W-40

E9-CJ-4-VDS-4.5
SAE 10W-40
SAE 10W-50
"SAE 15W-40"

E4 Scania LDF-3
SAE 10W-40

E7/CI-4
SAE 15W-40

E5/CH-4
SAE 15W-40

E5/CG-4
SAE 15W-40

NON CHEMICAL LIMITS

E6/E9/CK-4
Cummins 20081
MAN M3677, LDF-4
VDS 4/4.5
SAE 5W-30

E6/E9/CJ-4
Cummins 20081
MAN M3677, LDF-4
VDS 4/4.5
SAE 5W-30

E4 Scania LDF-3
SAE 10W-40

E7/CI-4
SAE 10W-40

OEMs
HTHSV ≥ 2.9
HTHSV ≥ 2.6

HTHSV ≥ 2.9
API FA4 – ACEA F

MB229.51
MB229.61

MB229.51

MB229.31

MB229.5

MB229.3

MB228.3

MB228.1

MB228.1
### MARKET REVIEW

**What have we seen so far?**

<table>
<thead>
<tr>
<th>Industry and Markets</th>
<th>Lubricant Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEMs leveraging fuel-efficient engine oils</td>
<td>Lower viscosity oils in factory and service</td>
</tr>
<tr>
<td>New materials and contact surfaces for improved FE</td>
<td>Oils compatible with new materials</td>
</tr>
<tr>
<td>Down-sized Direct Injection Gasoline</td>
<td>Oils capable of controlling / reducing LSPI</td>
</tr>
<tr>
<td>Steel Pistons enabling higher BMEP</td>
<td>Higher thermal oil stress</td>
</tr>
<tr>
<td>Thermal management</td>
<td>Higher average temperature of operation</td>
</tr>
<tr>
<td>Hybridisation / Stop Start</td>
<td>Cold start response and water handling</td>
</tr>
<tr>
<td>EGR and SCR</td>
<td>Potential for greater nitration and oxidation</td>
</tr>
<tr>
<td>Push for lower cost of ownership</td>
<td>Increased oil drain intervals challenge oil life</td>
</tr>
</tbody>
</table>