COMMERCIAL VEHICLES

Emissions Regulations Drive Change
Fuel Cells & Battery Electric
ICE Innovations Continue
CV Market Trends
Off-Road Trends
Global trucks sales remained flat compared to record breaking 2017 results, with just 1.6% growth in 2018.

Forecasters expect a decline in demand of 7% in 2019, although North America will likely buck this trend.

Gasoline and diesel continue to power most commercial vehicles but alternative powered vehicles are gaining attention.

Globally, fuel cost pressures, reducing total cost of ownership, and a global tightening of regulatory requirements, are driving greater efficiency from commercial powertrains.
Taking a look at the growth markets...

2018 was a very good year for commercial vehicle sales in Brazil, as the economy continued to recover. In 2022, tighter emissions compliance is required for new trucks and buses and by 2023, all existing models. Also, Biodiesel levels will increase from B10 to B15. These trends will advantage HDD lubricants meeting the latest specifications and their robust oxidation resistance and may drive extended drains.

Russia’s economy expanded more than expected in 2018 despite economic sanctions, by other countries. Commercial vehicle sales were up over 2017 reaching 82,000 units and domestic OEM KAMAZ leads with 30% market share. As of 2016, all vehicles must meet Euro V standards. Oils are upgrading from GOST oil grades to API CI-4 in both the on and off road.

India is one of the world’s fastest-growing economies and accounts for about 15% of global growth. 2018 sales were very strong, as fleets looked to comply with Bharat Stage 4 emissions regulations. In April 2020, India will jump straight to Bharat Stage 6, which will cut NOx and particulate matter emissions and introduce particulate number limits. Combined with tighter fuel economy in 2021, there’s high potential for a lubricant quality upgrade.

Finally, China has the largest truck market in the world with 4.3 million units sold last year, but economic growth in 2018, was the slowest in 30 years. Commercial vehicle production and sales enjoyed only modest increases in 2018. Sales of new energy commercial vehicles, represent about 5% of the market, and most are battery electric. Tighter emissions regulations are phasing in, which could drive demand for higher quality lubricants.

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>KEY TRENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAZIL</td>
<td>Strong growth as economy recovers</td>
</tr>
<tr>
<td>RUSSIA</td>
<td>Economy up 2.3%</td>
</tr>
<tr>
<td>INDIA</td>
<td>Strong economic growth</td>
</tr>
<tr>
<td>CHINA</td>
<td>Economy growth slowest in 30 years</td>
</tr>
</tbody>
</table>

- 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
- ~1 Million CV Sales up 27%
- Bharat Stage VI emissions in 2020
- Fuel economy tightens in 2021
- Production +1.7%
- CV Sales +5.1%
- Over 213K NEV CV sold, 80% BEV
- China VI phases in 2019-2023
- Oil Q-up expected

Oil Q-up expected
Emissions regulations continue to tighten globally.

In the US, Green House Gas Phase 2 standards begin to phase in with MY 2021 and in Europe, the European Commission proposed CO2 limits for new heavy-duty vehicles.

As more regions adopt tighter Euro 6 equivalent emissions, EGR and SCR exhaust aftertreatment will see wider use. We expect oil quality upgrades and a move to lower SAPS formulations.

This focus on clean air and cutting greenhouse gas emissions is driving innovation of the commercial powertrain, but also the entire vehicle.
OEMs are exploring a number of approaches to improve fuel efficiency.

Truck Platooning was jointly demonstrated by Volvo and FedEx last year and could result in fuel savings by reducing drag, for as few as 3 trucks platooning together.

Autonomous capability with predictive cruise control could offer considerable fuel savings through even closer platooning and greater asset utilization.

It’s clear OEMs see its value as explained by Suzanne Neal of Daimler Trucks North America.

NEAL- CVL-03 “Daimler is looking into Level 4 automation for the future. One of the reasons why is because the biggest variability in fuel economy is the driver-to-driver variation in the truck. Some of the impacts this might have on lubrication is that drivers might be looking for lubricants that have longer drain intervals and can withstand 24/7 operation.” 00:21

Also, OEMs are diversifying the energy source to help cut pollutant emissions, and decarbonize the commercial transport sector in specific applications.
Fully electric commercial vehicles are another approach to reduce pollutant emissions. Both Daimler and Volvo are introducing Class 8 battery electrics trucks.

PACCAR announced development of 10 hydrogen fuel cell electric Kenworth’s, in which Toyota Mirai hydrogen fuel cells generate electricity to charge lithium-ion batteries, powering an electric drive motor.

In parallel, CARB is also investing in a hydrogen refueling infrastructure.

Given their range, these fully electric Class 8s are intended for drayage at ports or, local to regional distribution applications.
However, electric and hydrogen fuel cell trucks face similar challenges. Without a “high-power” charging or hydrogen refueling infrastructure, and in the absence of mandates or grants, unless there is a proven economic advantage, the roll over to these new technologies will be slow in the long-haul segment.

Trucking currently accounts for half of diesel demand globally, and forecasters expect it to remain the dominant trucking fuel type globally through 2040.
Global Trends – ICE Continues to Improve

Turbo compounding – waste heat recovery
• Volvo – Improves FE by up to 6.5%
• Mack – Qualifies for EPA SmartWay
• Detroit – Up to 192 ft-lbs more torque for DD16 engine

Uptake depends on fuel economy gains vs. various costs

Other routes to FE through ICE hardware change
• Variable turbocharger geometry
• Low friction coatings
• On-demand auxiliaries
• Higher compression ratios
• Low friction piston design
• Automatic/Automated transmissions
• Light-weighting – new materials
• Advanced fuel injection strategies

Investments continue to be made in advancing the efficiency of the proven heavy-duty diesel powertrain.

Turbo Compounding is a form of waste heat recovery and while not new, it is seeing wider use by OEMs.

It uses a fixed turbine and coupling after the turbocharger to send power to the crankshaft.

Volvo increased fuel economy and Mack says its turbo compounding plus aerodynamic improvements raised the Mack Anthem’s fuel efficiency and qualified it for EPA’s SmartWay program.

Detroit Diesel uses turbo compounding on the DD16 to generate more torque for heavy haul applications.

OEMs are searching for the best combination of technologies that delivers the longest uptime and lowest total cost of ownership.

Here again with an example, is Suzanne.

NEAL-CVL-02 “Daimler is looking to expand our automated transmissions into our vocational market. One of the reasons why is to improve efficiency and reduce the impact on the fuel economy for driver variation.”
Examples of the technologies of tomorrow can be found in the SuperTruck II program, looking to double freight efficiency and improve engine brake thermal efficiency by 55%.

Participating are: Navistar, Daimler, Cummins, Volvo and most recently PACCAR.

Technologies being explored include: waste heat recovery, engine downsizing, hybridization, cylinder deactivation, and even alternative engine designs.
One radically different engine design is this 10.6 Liter two-stroke 3 cylinder opposed piston engine, with power equivalent to a conventional 15 Liter diesel.

Because the opposed pistons share the same cylinder, two crankshafts are required, however there's no cylinder head or valvetrain complexities.

A supercharger and turbo charger pressurize the intake to scavenge exhaust gasses, removing the pumping effort from the pistons.

This means lower fuel consumption, lower emissions, and a simplified engine and aftertreatment system.

At least 1 major OEM has expressed interest.
With our eye on the future, building on planned emissions legislation, EMA have given us a first glimpse of possible future lubricant requirements.

It’s likely that meeting 2024 Green House Gas Phase 2 requirements may need only evolutionary changes to hardware, and wider adoption of API FA-4. However, for 2027, significant engine changes are expected.

Also, EPA has announced plans to lower NOx limits in its proposed Cleaner Trucks Initiative. The new rule will be proposed in 2020 and could begin in MY 2024.

In addition, some CARB states may propose mandatory new ultra low NOx limits with a 90% NOx emission reduction from the current standard.

The resulting changes will likely impact lubricant performance and possibly lay the foundation for a new set of lubricant requirements and maybe PC-12.
Roger Gault of the Engine and Truck Manufacturers Association, explains upcoming emissions regulations, that may be laying the foundation for the need of a new API oil category and Suzanne returns to explain the potential impact on lubricant requirements.

GAULT-CVL-1 “The EPA Phase 2 GHG standards have three different steps: 2021; 2024; and 2027. 2021 is very near term; those engines are already designed. We don’t envision any requirements being changed in terms of lubricants for 2021. 2024, those engines are really close to being complete in terms of engine design, etc. I don’t envision a change in the lubricant standard requirements for 2024, but we may see more of a trend towards manufacturers adopting FA-4 as part of their 2024 strategy for compliance. For 2027 engine manufacturers are continuing to evaluate technologies that will be required to comply with those standards. There is an anticipation that if there was a change required in lubricants to meet any of these GHG standards, it would be 2027 standards because of the potential to change engine technologies and the resulting impact on lubricants.”

NEAL-CVL-09 “In order to meet future fuel economy targets, engine oils might have to go to lower viscosities, even lower than FA-4 is today”.

GAULT-CVL-2 “CARB held a workshop back in January of 2019, aimed at or increasing the durability of the emission control systems on heavy duty engines, and in particular, NOx after treatment systems
such as SCR. They are talking about, for example, increasing the useful life from 435,000 miles to a million miles. One of the major potential deterioration mechanisms for catalytic after treatment systems is chemical poisoning. And one of the sources of chemical poisoning is the lubricant that starts out in the engine crank case and then migrates through the engine and combustion process and into the exhaust stream.”

NEAL-CVL-10 “With the drive to increase the useful life of the engine and after treatment systems, we expect there to be an increased interest in the chemical effects on after treatment systems from engine oils. This could lead to tighter chemical limits for future engine oil categories”.

Looking closer at North America CVL market, the transition to API CK-4 was fast, as expected, with more than 1000 brands now licensed.

Unsurprisingly, the uptake of lower viscosity API FA-4 has been much slower.
Daimler’s Suzanne Neal and PetroCanada’s Barnaby Ngai offer their views on the slow adoption of API FA-4.

NEAL-CVL-06-07-11 “Some of the factors that have made FA-4 uptake slow in the marketplace are OEM acceptance and backwards compatibility. Daimler has received feedback from some of our fleets that API FA-4 is difficult to find on the aftermarket. However, for many suppliers, we’ve been told that it’s available in a variety of container sizes from small all the way to bulk load. Another factor that might have led to the slow uptake of FA-4 is at the beginning of the PC-11 launch it was noticed that some third party manufacturers such as cab heaters or refrigeration units were still recommending CJ-4 rather than CK-4 or FA-4 for use in their applications.“

NGAI-CVL-4 NGAI-CVL-4 “Basically the adoption rate of the FA-4 is as we expected. So, out of the gate, it's been slower, but as folks get more acclimatized from the changes from 15W40 to let's say, a 10W30, and then a 5W30, and then even as an extension of that, the FA-4 type lower viscosity oils, we’re going to start seeing a lot more comfort in those oils in terms of what they can do, the performance, the level of protection, and then you’re going to start seeing a larger adoption. “
Ron Romano of Ford updates us on the development of their 6.7L diesel valvetrain wear test.

ROMANO-CVL-2A “We're making some nice progress on this development of the 6.7L valve train wear test. Right now, we're in the middle of a prove-out running at 3 different labs. We're hoping that that'll be completed by mid-year, and once that's completed, we should be able to start planning for the precision matrix which we're hoping to get started by the end of the year.”

ROMANO-CVL-2B “We do plan on making the 6.7L valve train wear test an ASTM procedure. We'll go through all the procedures necessary to make sure that happens.”
Nathan Seibert of GM explains the specific oils recommended for their different diesel engines.

SEIBERT-CVL-01-02-03 “GM currently uses two different diesel engine oils. One is a CK-4 15W-40 for the 6.6L Duramax engines, and a Dexos 2 5W-30 for the 1.6L turbo diesel, and 2.8L Duramax diesel engines. GM is once again proud to be leading the industry with the introduction of the Dexos D 0W-20 diesel engine oil that will be launched with the 3.0L diesel engine found in the Chevy Silverado and the GMC Sierra pickups. This new oil will give the 3.0L Duramax engine improved fuel economy while maintaining the durability expected of a Duramax diesel engine.”
In the off-highway sector, the strong sales of 2018 continued in early 2019, but as the positive financial effects of tax cuts fade, and trade tariffs persist, demand is expected to soften. However, an infrastructure bill could boost equipment sales.

Electrification is finding applications in construction.

Caterpillar launched a new diesel hybrid electric bulldozer and Volvo CE are replacing their diesel-powered compact equipment, with full-electric, as part of their commitment to sustainable solutions.

Despite tariff concerns and low commodity prices,

Ag combine sales were up 18% in 2018 and with the current administration’s farm bill expected to provide farmers some stability in an uncertain market, most dealers are projecting a positive 2019 as well.
Barnaby returns to offer his perspective on lubricant trends in the off-highway segment.

NGAI-CVL-5 “So, one of the biggest trends we see is a gravitation towards higher-performing and often synthetic-type lubricants. And basically, that's all driven by the increasing need to maximize that uptime. So, that can come in the form of extended drains, that can come in the form of making sure that you protect those key vital components so that there's not any unplanned downtime. So, really what we're seeing in that off-road sector is a real understanding of what a higher-performing lubricant can do for their operations.”
In North American viscosity grade trends, SAE 15W-40 remains the most used viscosity grade by volume. However, as SAE 10W-30 has been HDD factory fill for several years, and as fleets cycle out older trucks, 10W-30 will continue to grow to become the predominate grade.

SAE 5W-30 & 40 grades will grow but are expected to remain a niche market.

GHG Phase 2 legislation will drive greater use of API FA-4 through the medium term, while 20 weight oils may start to appear, at the end of the next decade.
Barnaby returns to offer PetroCanada’s view on viscosity grade trends.

NGAI-CVL-3 “What does the future hold past that 3 to 5-year range as we get lower and lower in viscosity grades. So, you’re seeing a migration from 15W40 to 10W30, but you also have 5W30s. There’s also some talk about 0W20s; so really, how low can you go. And we’ll really need to answer that and support the industry in terms of the expertise required to make that transition.”
We close the CVL section with a look at Europe where efficiency improvement is a key driver of change to ACEA’s Heavy-duty oil sequences.

The inclusion of the Volvo T-13 oil oxidation test and Caterpillar C13 oil aeration tests has driven structural changes to the E categories.

Also, new Low Viscosity F categories have been introduced and 2 new wear tests in a low viscosity, low soot environment are currently under development.

The OM501 and OM646 are running out of hardware as ACEA works on replacements and we expect tighter limits for some tests. Test development progress continues to delay the next release date.