Latest Global Fuel Economy and CO₂ Compliance Prognosis

A focus on China, Europe, and the United States

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Enacted regulation
Convergence began in 2015

Gap closed to 40g/km eqv.
Enacting regulation
Matching the mature market target is one thing; executing is another

- It is necessary to meet the target, or face a penalty?
- Hardware is ready for the regulation, but is the consumer?
- Follow the methodology of developed markets
- Lack of clarity causes planning issues
- Coming from a low base and so proportionately much harder to reach target than developed markets
- Plan for the fuel consumption regulation, but no details now
- Very cost sensitive markets, and slow to introduce regulation

Done

- Developed countries are leading in fuel consumption
  • Set up the fuel consumption target and detail for process
  • Regulation for penalty payments for excess emissions
  • Trading market for credit and policy for pooling

Doing

- Emerging Markets are following this tendency
  • Set up the fuel consumption target and detail for process
  • Plan to have penalty payments for excess emissions
  • Design the credit calculation and policy for pooling

Planning

- Developing countries are setting up the planning for fuel consumption
  • Realized the importance of fuel consumption and set up the fuel consumption target, but no detail for process
  • Plan to have penalty payments for excess emissions
  • No detail design for the credit and pooling policy

Source: IHS Markit
US CAFE performance
Model year (MY) 2015 passenger car fleet by manufacturer

- Four manufacturers in MY2015 were significantly over-complying, generating credits to add to an already large credit bank
- “US Motors” as a whole over-complied in MY2015 at 36.7 miles per gallon (mpg)
- Five manufacturers that needed to spend/purchase credits in order to comply and are behind the curve in preparation for the next MY cycles
US CAFE performance
MY2015 light truck fleet by manufacturer

- Five truck manufacturers in MY2015 were over-complying, generating credits for future use, or to sell to those below the line
- "US Motors" as a whole come close, but did not quite achieve target in MY2015 at 26.2 mpg
- Four volume manufacturers that needed to spend/purchase credits in order to comply and are behind the curve in preparation for the next MY cycles
Regulatory performance in 2015

**EU CO₂ performance**

Calendar year (CY) 2015 passenger car fleet

- Diesel downsized engine with significant mass actions
- Mostly in A- and B-segments, MPVs
- SUV market is slowly being explored

- Sales in A- and B-segments are compensating high take rates of SUVs
- Noticeable improvements from start-stop system

- An intensely competitive Europe **met** the 2015 average CO₂ target, achieving a status of **119.6 g/km.**
- The average mass of new cars sold in the European Union (1381 kg) remained broadly the same as compared with 2014.
- Diesel made up **52%** of EU sales, with a 50% sales increase for BEVs compared with 2014. However, overall PHEV and BEV share was just **1.3%.**
A number of low volume manufacturers in CY2015 missed Phase 3 compliance, yet encouragingly, a larger amount of manufacturers, both domestic and imports complied, some of them significantly, proving that they have the tech strategy ready for Phase 4.

“China Motors” as a whole hit the precise target of 6.9L in 2015.
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Regulatory proposals beyond 2015

Target trajectory convergence
Markets start to align below 100g/km equivalent

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<th>Year</th>
<th>Region</th>
<th>Emission Standard (g/km)</th>
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<tr>
<td>2015</td>
<td>China</td>
<td>164</td>
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<tr>
<td>2016</td>
<td>Mexico</td>
<td>145</td>
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<td>2017</td>
<td>Brazil</td>
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<td>2018</td>
<td>KSA</td>
<td>142</td>
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<td>2019</td>
<td>India</td>
<td>130</td>
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<td>2020</td>
<td>EU</td>
<td>122</td>
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<tr>
<td>2021</td>
<td>Japan</td>
<td>117</td>
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<td>2022</td>
<td>India</td>
<td>113</td>
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<td>2023</td>
<td>Korea</td>
<td>97</td>
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<td>2024</td>
<td>US &amp; Canada</td>
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United States currently reviewing its regulation
CAFÉ and GHG midterm review TAR process

175 g/mile of CO₂ in 2025

- Fleet car/truck mix
  - 2012 final rule was 67/33% in 2025
  - Reference for TAR is 52/48% in 2025
- Footprint based standards will likely not change
- TAR shows that MY 2022–25 standards can be achieved through advanced gasoline vehicle technologies
- Low-cost electrification

46.3 mpg in 2025 (unadjusted)
37–39 mpg (real world)
Regulatory proposals beyond 2015

EU28 always reviewing its regulation

2015 thru 2030 pegged at 48% reduction max

Image Source: Institute for Automotive Engineering (ika), RWTH Aachen University, Germany (2015 Aachen conference)

Data Source: EUROPEAN ENVIRONMENTAL AGENCY (EEA) Monitoring CO2 emissions from passenger cars and vans Copenhagen, Denmark, 2015
**Regulatory proposals beyond 2015**

**China Phase IV now released**

Attention now turns to 4L for Phase V for 2025?

\[
CAFC = \frac{\sum_{i=1}^{N} FC_i \cdot V_i}{\sum_{i=1}^{N} V_i \cdot W_i}
\]

- \( i \) — vehicle \( i \)
- \( FC_i \) — actual fuel consumption of vehicle \( i \)
- \( V_i \) — actual production or import volume of vehicle \( i \)
- \( W_i \) — super credit for vehicle \( i \)
- \( CAFC \) — corporate average fuel consumption

**Notes:**
- PHEV should meet E-range>= 50KM
- Energy saving vehicle should meeting the fuel consumption <=2.8L/100km
Challenges and consequences
An example—Moving to WLTP has four dimensions, not easy for the OEM

Best aero, mass, and tire
Start temp: 20–30°C

Worst and best aero, mass, and tire
Start temp: 23 +/-5°C
Plan for 14°C in EU

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*Source: AVL Tech Day 2014
Challenges and consequences
How WLTP, NO\textsubscript{x}, and CO\textsubscript{2} are now changing the diesel landscape in Europe

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Source: VPaC Technology Analytics
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Forecast methodology
Overarching boundary considerations

Source: IHS Markit
What is VPaC?

- VPaC is a web-based vehicle energy and performance analytics software suite.
- Vehicle energy demand versus propulsion energy are computed for all possible vehicle fleet combinations.
- The software is designed for strategy planning and competitive vehicle analysis.
- Drawing on IHS Automotive SBPT as input, it considers entire forecast fleets and individual vehicles, not just current fleets or single-vehicle simulations.
- VPaC puts CO₂, FC and FE computation into the competitive context and expands the appeal beyond traditional engineering.
The most challenging geography. Macro conditions lead to a tech demand split forecast that is not conducive to compliance. Much greater electrification is the solution, but the demand pull is hard to envisage.

Having said this, there are three OEMs that despite the macro environment, are coming from such a high base that they will comply.

Some manufacturers will comply in Europe given our baseline tech split forecast, although the fleet as a whole is expected to miss by 10%.

However, we can quite easily envisage the EU28 fleet complying to 95g with some minor adjustments to mix. 2025 becomes the challenge for Europe.

Some manufacturers are very close to Phase 4; we see the correct strategy at the right time; incentives tweak required.

However, clearly some manufacturers are not planning effectively for the compliance challenge. Similar to the US in that much greater NEV is required, but enough consumer pull is hard to envisage.
Baseline technology forecasts

Technology demand prognosis – Global

Major technology sets only – passenger car & SUV sales
Why 48v MHEV?
More than just a stepping stone and its globally applicable

• 12V provides very limited scope to reduce CO₂. High voltage is expensive. Hence, the right blend is of mild hybrid with different cost-benefit ratio to encourage CO₂ reduction.

• Up to 15% fuel economy improvement, with Load offset and Better energy harvesting

Fuel economy benefit

- Charging
- Start-stop
- Recuperation
- Slow speed start-stop
- Torque boost
- E-sailing, coasting, creeping
- Start-stop < 20Kph
- Torque assist and boost

<table>
<thead>
<tr>
<th>Year</th>
<th>48V MHEV EU28 Sales</th>
<th>48V MHEV U.S Sales</th>
<th>48V MHEV China Sales</th>
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<tbody>
<tr>
<td>CY2015</td>
<td>0%</td>
<td>5%</td>
<td>10%</td>
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<tr>
<td>CY2025</td>
<td>20%</td>
<td>15%</td>
<td>25%</td>
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Why 48v MHEV?
A variety of configurations capturing non-traditional suppliers

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<td>E-water pump</td>
<td>E-compressor</td>
<td>Infotainment and HMI</td>
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<tr>
<td>E-fan</td>
<td>E-vacuum pump</td>
<td>Navigation and speaker</td>
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<tr>
<td>E-fuel pump</td>
<td>E-steering pump</td>
<td>Pre-heating</td>
</tr>
<tr>
<td>E-clutch</td>
<td>E-catalyst</td>
<td>Lights</td>
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<tr>
<td>E-turbo</td>
<td>Interior fan</td>
<td>Windscreen and wiper</td>
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<td>E-oil pump</td>
<td>Active aerodynamic</td>
<td>Seats</td>
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Baseline technology forecasts

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Baseline technology forecasts

Why 48v MHEV?
Policy vs. cost vs. consumer – The rise of the MHEV in China

Units: Million vehicles

China government definition for energy-saving vehicle
- Benefit in CAFC
- Subsidy by some local government

China government definition for NEV
- Benefit in CAFC
- Subsidy by government

China Gov. target in 2020:
NEV annual production = 2 million
(Passenger Car + LCV + HCV)

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In general

• Global vehicle CO₂, fuel economy, and fuel consumption regulations are continually tightening, resulting in significant increases in research and development spending and planning complexity.

• A sole focus on internal combustion engine (ICE) improvement will not be sufficient to achieve the upcoming targets in United States, EU28, or China. Electrification and vehicle measures reducing rolling resistance and aero drag are required.

• CO₂ emissions reduction technologies also add costs to vehicles for being CO₂ compliant. Therefore, every type of electrification is monitored by car manufacturers and potential car buyers with regard to its cost-benefit ratio.

• WLTC introduction is expected to reduce the gap between certified and real-world fuel economy CO₂ figures. However, overall vehicle development costs will likely increase.

• Scenarios developed using VPaC show that the industry HAS the hardware to meet the regulation, but not the consumer demand in our baseline scenario.

• It is particularly hard to envisage the necessary consumer demand being present in the United States.
CAFC regulation now dominates the technology roadmap for auto manufacturers in China.

Both joint venture and domestic OEM’s in China are facing serious challenges to meet the CAFC regulation in 2020 and 2025, although the joint ventures will leverage overseas experience and hardware sets.

The luxury/premium vehicle has a proportionately stronger compliance headwind compared to volume manufacturers, despite the margin available to spend.

Neither traditional technology nor NEV on its own will be enough to meet the CAFC regulation separately in 2020 and 2025. A difficult consumer pull outlook for NEV’s will result in OEM’s and the government needing to lean on the ESV (Energy Saving Vehicle).

Comprehensive solutions will lead to more complex technology roadmap for OEM’s; increasingly, planners need to consider the balance of consumption, performance, cost, and regulation.
Thank you