How to get to Euro VI

Kate Blumberg
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Regulatory development

1. Regulatory design
2. Regulatory impact assessment & benefits of leapfrogging
3. Fuel quality & urea supply
4. Compliance, enforcement & verification
Euro VI has been adopted by four countries: Mexico, Brazil, Colombia and Peru.

Costa Rica requires DPFs.

Mexico has now rolled back standards by at least four years.
1. Regulatory design
Regulatory design

Full standard includes
- Durability
- OBD
- NTE
- WHDC
- In-service conformity

Euro VI- Commercial Vehicles have been designed to reduce Nox and PM10, PM 2.5 under real life conditions

Comparison of local emissions

Euro VI ‘behind the scene’

- More than just two limits on NOx and PM - technical issues which are usually not known:
  - Durability procedures
  - 700,000km (Euro V: 500,000km)
  - Onboard Diagnosis
  - SCR (inducement measures)
  - Off Cycle Emissions (NTE limit)
  - CI-Factor (WHSC): 1.5
  - Particle Measurement Procedure Validation
  - 1st-time applied testable with number of particulates
  - World Heavy Duty Cycle (WHDC)
  - First world-wide harmonized test-cycle mainly driven by Daimler
  - Test cycle applied to Euro VI standard (with significant cold start)
  - In Service Conformity (PEMS)
  - Checking customer vehicles for emissions conformity with portable measurement systems

* Euro VI Test procedures focus not only on test bench measurements but also on fulfillment of emission requirements in real life driving

* source: ICCT Report March 2015
WHDC, NTE, OBD as important as g/kWh

Euro IV and V standards did not achieve reductions off the certification test cycle. Real-world benefits are a result of comprehensive regulatory design.
Cautionary tale #1: Brazil

<table>
<thead>
<tr>
<th>Defeat Pathway</th>
<th>OBD monitoring strategies</th>
<th>Inducement Triggered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ARLA-32 Level</td>
<td>ARLA-32 Consumption/Quality or Direct NOx monitoring</td>
</tr>
<tr>
<td><strong>EURO V</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disrupt signal from sensors</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Use an alternate fluid</td>
<td>●</td>
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</tr>
<tr>
<td>Loop outflow back into tank</td>
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<td>●</td>
</tr>
<tr>
<td>Use no fluid</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>P-J</strong></td>
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</table>

* Monitoring strategy does not indicate malfunction; ● Monitoring strategy indicates malfunction; N/A Monitoring strategy not available
* Consumption may be inferred, not directly measured
** If system is reset within 48 hours of malfunction being detected, inducement will not be triggered.

Brazil weakened Euro V standards, allowing for even higher emissions than in EU.

- With proper OBD design, vehicle use is inhibited if system cannot function.
- Vehicles in Brazil do not incorporate these critical sensors and inducements.
2. Regulatory impact assessment & benefits of leapfrogging
Regulatory impact assessment

Cost-benefit assessments regularly find benefits of Euro VI adoption are several times greater than the costs.

- Leapfrogging from Euro II or III to Euro VI provides a greater benefit to cost ratio as health impacts related to particulate matter are estimated based on mass of emissions reduced. Mexico benefit to cost ratio = 11
- But benefits still outweigh costs from Euro IV or V to Euro VI. Argentina benefit to cost ratio = 3.6
Emissions factors

- While Euro VI reduces PM emissions from Euro V by a greater %, the total mass of emissions reduced by Euro V is greater.
- NOx emissions reductions are greater in both % and mass.
The Euro VI by 2021 scenario avoids a cumulative 100,000 tonnes vs. Euro VI by 2023 over the period 2021–2035.
Argentina cost-benefit: PM$_{2.5}$ emissions

The Euro VI by 2021 scenario avoids 1,000 tonnes vs. Euro VI by 2023 over the period 2021–2035

Baseline emissions reduction as new Euro V HDVs gradually replace the oldest cars

Scenario
- Baseline (Euro V)
- Euro VI by 2021
- Euro VI by 2023
- Euro VI by 2025

Baseline emissions (-90%)
Argentina cost-benefit: Technology costs

Incremental technology costs from Euro V to Euro VI range from $1,000–$1,500 per vehicle (including direct and indirect costs).

Indirect costs = 12.5% direct manufacturing costs

- VGT = Variable-geometry turbocharger
- OBD = On-board diagnostics
- SCR = Selective catalytic reduction
- DPF = Diesel particulate filter
Argentina: Costs and benefits

Over a 30-years, every $1 invested in Euro VI would produce $3.6 in health benefits.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Cumulative private costs (million U.S.$)</th>
<th>Cumulative health benefits (million U.S.$)</th>
<th>Net benefits (million U.S.$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro VI by 2021</td>
<td>325</td>
<td>776</td>
<td>451</td>
</tr>
<tr>
<td>Euro VI by 2023</td>
<td>267</td>
<td>593</td>
<td>327</td>
</tr>
<tr>
<td>Euro VI by 2025</td>
<td>213</td>
<td>433</td>
<td>219</td>
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Over 15 years, benefit to cost ratio > 2.

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<td>Euro VI by 2021</td>
<td>620</td>
<td>2,202</td>
<td>1,583</td>
</tr>
<tr>
<td>Euro VI by 2023</td>
<td>559</td>
<td>1,990</td>
<td>1,432</td>
</tr>
<tr>
<td>Euro VI by 2025</td>
<td>502</td>
<td>1,787</td>
<td>1,285</td>
</tr>
</tbody>
</table>

Over a 30-years, every $1 invested in Euro VI would produce $3.6 in health benefits.
Mexico: Air quality benefits

<table>
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<tr>
<th>Air quality indicator (population-weighted)</th>
<th>Nationwide</th>
<th>Mexico City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual mean PM$_{2.5}$</td>
<td>-18%</td>
<td>-20%</td>
</tr>
<tr>
<td>8-hour maximum ozone</td>
<td>-8%</td>
<td>-5%</td>
</tr>
<tr>
<td>1-hour maximum ozone (spring mean)</td>
<td>-12%</td>
<td>-14%</td>
</tr>
</tbody>
</table>

In the example of Mexico, updating HDV emissions standards will have ~twice the benefit of updating LDV standards. Direct diesel PM emissions have the greatest health impact.

<table>
<thead>
<tr>
<th></th>
<th>HDVs</th>
<th>LDVs</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
</table>
| Ozone         | 900  | 1,100| 2,000 | 22%
| Secondary PM  | 1,400| 1,700| 3,100 | 34%
| Primary PM    | 3,900| 0    | 3,900 | 43%
| Total PM      | 5,300| 1,700| 7,000 | 78%
| Total         | 6,200| 2,800| 9,000 | 100%
| %             | 69%  | 31%  | 100%  |
3. Fuel quality & urea supply
10-15 ppm sulfur diesel is important
  • Euro VI vehicles need this fuel to meet emissions standards
  • PM emissions are also reduced for older vehicles in the fleet using lower sulfur fuel
  • Emissions controls can recover from occasional use of higher sulfur fuel, but regular use could cause lasting damage and would reduce durability of systems

Diesel exhaust fluid is also important
  • The main component of DEF is urea, a common product with many uses
  • Distribution systems have generally sprung up quickly for this product to be sold in fuel stations, as soon as vehicles require it.
Cautionary tale #2: Mexico

Mexico’s HDV emissions standard (NOM-044) is linked to the fuel quality standard, requiring 100% of the diesel to meet the 15-ppm sulfur standard.

Full implementation of diesel standard has been delayed from 2009 to 2019, now to 2025 at the earliest.

SEMARNAT rolled back vehicle standards to match this date even though more than 80% of the diesel meets 15 ppm standards.
Cautionary tale #2: Mexico

The cost of the 3-year delay:

- Approaches USD 15 billion over 20 years
- On the other hand, expanding standards to used vehicles offers USD 20 billion in value
- Accelerating fleet renovation almost doubles that
- USD 15-50 billion in benefits lost through the 3-year rollback
A dual fuel approach can work

MX truck manufacturer association told the government, “There is no country in which a technology has been made obligatory, if the fuel is not available first.”

TRUE, but many countries have not required compliance for 100% of the fuel.

A few examples...

**Brazil**

Mexico

United States

## Dual fuel requirements for success

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Pricing</th>
<th>Labeling</th>
<th>Enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Lower sulfur fuel must be available on major corridors &amp; at regular intervals, accompanied by consumer awareness campaigns</td>
<td>• Lower sulfur fuel must be priced competitively with higher sulfur fuel, even better is to provide a price or tax advantage</td>
<td>• Fuels must be clearly labeled at the pump and there should also be labeling on the vehicle stating the need to refill with lower sulfur diesel</td>
<td>• Enforcement campaigns should provide consumers with confidence that they are getting the proper fuel</td>
</tr>
</tbody>
</table>
4. Compliance, enforcement & verification
### Compliance

Ensure that the registered vehicles meet regulatory requirements:
- Identify cases of noncompliance when they exist
- Such as pre-, in-, and post-production vehicle

### Enforcement

Hold responsible parties accountable and correct the situation:
- When vehicles are found to be out of compliance with the standards
- Such as noncompliant vehicle recalls and financial penalties

### Verification

Ensure vehicles are operating as intended
- Remote sensing
- Fleet programs
## Maintenance requirements

<table>
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<tr>
<th>Technologies</th>
<th>Euro IV</th>
<th>Euro V</th>
<th>Euro VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR or SCR</td>
<td>EGR / SCR</td>
<td>EGR / SCR / DPF</td>
<td></td>
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</tbody>
</table>

| Lubricating oil      |             |            | E9, APT CJ-4 (low SAPS)      |

| Fuel                 |             |            | Low sulfur diesel            |

| AdBlue DEF           | Standard 2-4% | Standard 3-5% | Standard 4-7% |

| DPF                  |              |              | Maintenance after 300’000-500’000 km |

| SCR dosing unit      | Filter replacement | Filter replacement | Filter replacement |

| Breather filter      | Replacement    | Replacement    | Replacement          |

| Sensors              | NOx sensor     | NOx sensor     | NOx/NH3 sensor       |
7 C&E Best Practices

1. Establish clear legal authority
2. Avoid conflicts of interest
3. Obtain the necessary resources
4. Conduct reliable testing at all stages (production/use)
5. Use corrective actions
6. Prioritize data and information transparency
7. Create a roadmap for program development
Recommendations for developing countries

**Sufficient funding** for enforcement programs
- Example: Certification fees covering the costs

**Clear legal authority** for compliance & enforcement activities
- Need authority to conduct in-use testing, investigate defeat devices, force recalls for failure to comply, and impose fines

**In-use testing and recalls**
- Include vehicles at higher mileage (50,000 km - 100,000 km)
- Recall if > 50% of the tested vehicles fail to meet the standards
- A robust in-use testing program can reduce effort needed on the pre-production program

**Remote sensing programs**
- Low-cost way to help track and identify issues that need more attention: New vehicles, deterioration, differences between manufacturers, high emitters, defeat devices for SCR systems
- Provide support for and confirmation of inspection & maintenance programs
Additional Recommendations

**Independent testing**
- Having access to independent laboratory facilities for pre- and post-production tests is best.

**Emission warranty provisions**
- Defect reporting requirements
- Puts pressure on manufacturers to develop and provide more robust emissions control systems, better for consumers

**OBD and I&M**
- Detect use of consumer defeat devices for SCR systems, when the urea tank has not been refilled with urea or is not dosing properly

**Defeat device provisions**
- These require a high degree of expertise for enforcement
- Remote sensing can help identify problems

**Data transparency**
- Difficult in all markets
Recommendations

1. Adopt the full standards, especially including test cycles and OBD
   ➢ Emissions limits are not sufficient to achieve the real-world benefits
2. Leapfrog directly to Euro VI
   ➢ Most cost-effective approach
3. A dual fuel approach can work well & the private sector will meet the urea demand
   ➢ Distribution & marketing, pricing, labeling and enforcement will make this approach successful
4. Compliance, enforcement & verification is increasingly important
   ➢ Funding and authority are the 1st priority, in-use testing and remote sensing are the 2nd
Thank you!
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