LSPI and Fuel Economy – What is the Future Outlook?

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Will LSPI limit the automotive industry’s ability to meet future CO$_2$ and fuel economy targets?
Our CO₂/Fuel Economy Target is Aggressive

ICCT: EU CO₂ Emission Standards for Passenger Cars and Light-Commercial Vehicles, January 2014

23-43 mpg for US window sticker
The Fuel Economy Challenge Will Not be Solved by Hybrids

Market share of HEV’s in major global markets
ICCT: Technical Brief July 2015
The Industry Path to Efficiency: Downsizing, Turbocharging, GDI

<table>
<thead>
<tr>
<th></th>
<th>2011 328i</th>
<th>2012 328i</th>
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</thead>
<tbody>
<tr>
<td>Cylinder count</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Displacement</td>
<td>2996 cc</td>
<td>1997 cc</td>
</tr>
<tr>
<td>Power</td>
<td>170 kW</td>
<td>180 kW</td>
</tr>
<tr>
<td>Max BMEP</td>
<td>11 bar</td>
<td>22 bar</td>
</tr>
<tr>
<td>EPA Combined FE</td>
<td>22 mpg</td>
<td>27 mpg</td>
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Must be ~34 mpg in 2025
We Achieved a Massive Efficiency Gain, But at What Cost?

Spark timing = 3 deg aTDC

LSPI!
Ford 3.5 L EcoBoost Engine
SwRI: SAE Paper 2011-01-0342
Engine Failure from LSPI is Unpredictable and Expensive
Can We “Solve” LSPI?

Better living through lubricant chemistry*

* Assuming the engine power density doesn’t increase

Infineum: SAE Paper 2015-01-0717
Without a Solution, LSPI Limits Downsizing

More downsizing → higher BMEP

Higher BMEP → more LSPI

More LSPI → A bad day
The Past Future of Fuel Economy

Mahle: DEER 2011 Presentation
The New Future of Fuel Economy

GASOLINE ENGINE 2020
200 g/kWh or 200 kW/l?

Guenter Fraidl
AVL List GmbH

TARGET 2020
“200 kW/L”
COMMON BASIS
- Adv. Combustion
- Efficient charging
- Friction Reduction

Fuel Economy Concepts
(high production volume)

“200 g/kWh”

AVL: 2015 SAE High Efficiency Engine Symposium
Lowering BMEP Makes LSPI a Solvable Problem

P3-Protocol LSPI Test Results – High LSPI Simulated Market Fuel
Other Efficiency Technologies Support LSPI Reduction

SwRI: SAE Paper 2011-01-0342

GM: SAE Paper 2011-01-0340
An LSPI-Free Engine of the Future

GF-6
We can achieve compliance with future CO₂ regulations while minimizing the risk of LSPI and while maintaining vehicle performance for customer satisfaction.
Thank you

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