eBoosting® the Gasoline Engine Evolution

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Outline

- Gasoline Engine Evolution:
  - The Past
  - The Present
  - The Future

- Turbocharging products with electrification
  - eBooster®
  - eTurbo

- Conclusions
Gasoline Engine Evolution: The Past

- Engines were generally larger in Displacement
- Very Cost Effective Solution for vehicle propulsion
- Calibration and Control was straight forward
Engine Downsizing with Turbocharging is Mainstream
Direct Injection Fuel Systems are a nice compliment to Turbocharging
Fuel Economy Improved without Sacrificing Performance
Gasoline Engine Evolution: The Future

- Advanced Turbocharged Engines Emerge by 2020
- 48V Mild Electrification promotes eBooster®
- Engines benefit from advances in microprocessors for simulation, optimization, and control
eBooster® Video

- https://youtu.be/eXWAPNOAuv0
Typical System Layout
eBooster® key benefits

- Enhanced transient boost response
- Reduced emissions level
  - New degree of freedom in air path control
- Enables downsizing without “turbo-lag”
- Enhanced low-end torque (LET)
- Enabler for further down-speeding
- Reduced fuel consumption
Phase 1 – Normal Driving

Phase One
Constant drive in high gear with medium speed and low load - eBooster® is inactive
Phase 2 – Acceleration

Driver hits the pedal (acceleration trip) eBooster® supports the turbocharger until it can provide the demanded pressure.
Phase 3 – Return to Normal Operation

- Bypass Valve
- Waste Gate Valve
- Intake Air
- Turbocharger has reached equal or greater required pressure - eBooster® reduces speed until inactive

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**BorgWarner 48V eBooster® Demo Car**

**2015 Ford Mustang 2.3L EcoBoost**

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**35% Fuel Economy through Downsizing**
- eBooster with 5kW peak
- More Low End Torque
- Faster Torque Response Time

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<table>
<thead>
<tr>
<th>(*)DATA MEASURED @ REAR WHEELS</th>
<th>2.3L turbo (mod. series)</th>
<th>2.3L w/ eBooster® and matched turbo</th>
<th>5.0L V8 Nat. Aspirated (series)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque @ 2000rpm (ft-lbs)(*)</td>
<td>275</td>
<td>320</td>
<td>290</td>
</tr>
<tr>
<td>Peak Power (hp)(*)</td>
<td>310</td>
<td>415</td>
<td>385</td>
</tr>
<tr>
<td>Time to 250 ft-lbs @ 1500rpm (sec.)(*)</td>
<td>1.25</td>
<td>0.95</td>
<td>0.35</td>
</tr>
<tr>
<td>City Fuel Economy (mpg)</td>
<td>22</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Hwy Fuel Economy (mpg)</td>
<td>31</td>
<td>32</td>
<td>25</td>
</tr>
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eTurbo - The next generation of Turbocharger Electrification

- eTurbo integrates a turbocharger and an eBooster® into one unit.
- eTurbo has all the features of an eBooster with two additional benefits
  1. Ability to recoup exhaust heat energy into electricity for additional fuel economy improvements
  2. Simplified plumbing for improved under hood packaging
In Conclusion...

- Fast pace of innovation in turbochargers and turbocharged engines continues to push the leading edge of IC engines.
- eBooster® and eTurbo are two technologies that will continue to improve the efficiency and performance of internal combustion engines.
- System approaches including Variable Valve Lift systems, Cooled External EGR, Fuel Injection, and Advanced Ignition systems promote well rounded solutions to many challenges of turbocharged engines.
- One solution won’t emerge, however a broad range of solutions and strategies will be used to meet specific requirements of vehicles.
Thank You

feel good about driving

Fuel Economy  Emissions  Performance