## Advanced Internal Combustion Engine & Powertrain Technologies

### Selected Advanced PowerTrain Technologies (currently in production)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Average Efficiency Increase</th>
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<tbody>
<tr>
<td><strong>Variable Valve Timing &amp; Lift</strong></td>
<td>5%</td>
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<tr>
<td>Improve engine efficiency by optimizing the flow of fuel &amp; air into the engine for various engine speeds.</td>
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<tr>
<td><strong>Cylinder Deactivation</strong></td>
<td>7.5%</td>
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<tr>
<td>Save fuel by deactivating cylinders when they are not needed.</td>
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<tr>
<td><strong>Turbochargers &amp; Superchargers</strong></td>
<td>7.5%</td>
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<td>Increase engine power, allowing manufacturers to downsize engines without sacrificing performance or to increase performance without lowering fuel economy.</td>
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<tr>
<td><strong>Integrated Starter/Generator (ISG)</strong></td>
<td>8%</td>
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<td>Systems automatically turn the engine on/off when the vehicle is stopped to reduce fuel consumed during idling.</td>
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<tr>
<td><strong>Direct Fuel Injection</strong></td>
<td>11-13%</td>
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<td>(w/ turbocharging or supercharging) delivers higher performance with lower fuel consumption.</td>
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<tr>
<td><strong>Continuously Variable Transmissions (CVTs)</strong></td>
<td>6%</td>
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<td>Have an infinite number of &quot;gears&quot;, providing seamless acceleration and improved fuel economy.</td>
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<tr>
<td><strong>Automated Manual Transmissions (AMTs)</strong></td>
<td>7%</td>
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<tr>
<td>Combine the efficiency of manual transmissions with the convenience of automatics (gears shift automatically).</td>
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(savings estimates from www.fueleconomy.gov)
Cost/Efficiency Ratio of New Engine Concepts
Based on Current V6 SI-Engines – FEV Estimates 2004

Saving of Fuel Consumption %

Additional Production Costs, US Dollars

V6

EAT

VCR

GDI

EMV

VDE

TDI

Adv. TDI

EAT- Electric Assisted Turbo charging
VCR -Variable Compression Ratio
GDI - Gasoline Direct Injection
EMV- Electric Magnetic Valve Train
TDI - Turbo Charged (Diesel) DI
VDE- Variable Displacement Engine
HEV- Hybrid Electric Vehicle

Conventional Gasoline Engines

Share of Advanced Technologies

Conventional Multi Port Injection (MPI)
Variable Valve Timing & Lift (VVT&L)

Also called variable valve actuation (VVT), variable-cam timing and variable valve timing and lift electronic control (VTEC®)

Valves control the flow of air and fuel, into the cylinders and exhaust out of them. When and how long the valves open (timing) and how much the valves move (lift) both affect engine efficiency.

Optimum timing and lift settings are different for high and low engine speeds. Traditional designs, however, use fixed timing and lift settings, which are a compromise between the optimum for high and low speeds. VVT&L systems automatically alter timing and lift to the optimum settings for the engine speed.

Honda DOHC i-VTEC® System enhances the effect of VTEC® on Accord's 4-cylinder engine by adding variable timing control, or VTC. (click for web link)

Nissan's Continuously Variable Valve Timing Control System (CVTCS) measures intake flow and engine rpm, then continuously adjusts the moment each valve breathes in. And it does this throughout the power band — from that first boost off the line to when you approach redline. Response time and efficiency are optimized. Power and torque, too. View for link to web demo
Toyota VVT-i, or Variable Valve Timing with Intelligence

The Toyota VVT-i system replaces the Toyota VVT offered starting in 1991 on the 4A-GE 20-Valve engine. The VVT system is a 2-stage hydraulically controlled cam phasing system.

BMW VALVETRONIC system is based on BMW's double-VANOS (or variable adjustment of the camshafts), with infinite camshaft adjustment to meet specific requirements.

The additional, variable valve lift adjusts the effective cam action and, accordingly, the opening cross-section of the valves.
Cylinder Deactivation

Also called *multiple displacement, displacement on demand (DOD)*, and *variable cylinder management*

This technology merely de-activates some of the engine’s cylinders when they are not needed. This temporarily turns a 8- or 6-cylinder engine into a 4- or 3-cylinder engine. This technology is not used on 4-cylinder engines since it would cause a noticeable decrease in engine smoothness.

GM’s Displacement on Demand

Displacement on Demand automatically turns off half of the cylinders during light-load operating conditions, enabling the working cylinders to achieve higher fuel efficiency through better thermal, pumping and mechanical efficiency.

Under light loads, the control module automatically closes both intake and exhaust valves for half of the cylinders.
TurboCharging & Supercharging

Turbochargers and superchargers are fans that force compressed air into an engine's cylinders. A turbocharger fan is powered by exhaust from the engine, while a supercharger fan is powered by the engine itself. Both technologies allow more compressed air and fuel to be injected into the cylinders, generating extra power from each explosion. A turbocharged or supercharged engine produces more power than the same engine without the charging, allowing manufacturers to use smaller engines without sacrificing performance.
Spark Ignition - Direct Fuel Injection

Also called *fuel stratified injection* or *direct injection stratified charge*. In conventional multi-port fuel injection systems, fuel is injected into the port and mixed with air before the air-fuel mixture is pumped into the cylinder. In direct injection systems, fuel is injected directly into the cylinder so that the timing and shape of the fuel mist can be precisely controlled. This allows higher compression ratios and more efficient fuel intake, which deliver higher performance with lower fuel consumption.

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Integrated Starter/Generator (ISG)

These systems automatically turn the engine off when the vehicle comes to a stop and restart it instantaneously when the accelerator is pressed so that fuel isn’t wasted for idling. In addition, regenerative braking is often used to convert mechanical energy lost in braking into electricity, which is stored in a battery and used to power the automatic starter.
Automated Manual Transmission (AMT)

Automated manual transmissions combine the best features of manual and automatic transmissions. Manual transmissions are lighter than conventional automatic transmissions and suffer fewer energy losses. However, most drivers prefer the convenience of an automatic. AMT operates similarly to a manual transmission except that it does not require clutch actuation or shifting by the driver. Automatic shifting is controlled electronically (shift-by-wire) and performed by a hydraulic system or electric motor. In addition, technologies can be employed to make the shifting process smoother than conventional manual transmissions.

Continuously Variable Transmission (CVT)

Most conventional transmission systems control the ratio between engine speed and wheel speed using a fixed number of metal gears. Rather than using gears, the CVTs in currently available vehicles utilize a pair of variable-diameter pulleys connected by a belt or chain that can produce an infinite number of engine/wheel speed ratios.

This system has several advantages over conventional transmission designs:
- Seamless acceleration without the jerk or jolt from changing gears
- No frequent downshifting or "gear hunting" on hills
- Better fuel efficiency
Audi MultiTronic CVT

The multitronic® is a continuously variable transmission with a steel link-plate chain running in tension in an oil bath between two pairs of bevel wheels of variable diameter. It can transmit torque of up to 310 Nm - a world-first for this kind of transmission.
Other Technologies

- Homogeneous Charge Compression Ignition (HCCI)
- Variable Air Intake Geometry

- Others???

Nissan's Variable Air Intake

Maxima's variable air intake system features an intake manifold that "breathes" differently at high and low rpm. You get rich torque off the line; then, as speeds rise, a shorter air flow path opens. [View Web Link Demo](#)