Beyond hybrids and electric cars: Green driving adds sensors, telematics and a bit of social engineering to the eco-mix

The mission of reducing hydrocarbon emissions from vehicles rolls along two tracks: Make every component of the vehicle (not just the engine) more efficient; and, make the trip from point A to point B as efficiently as possible. NXP Semiconductors takes a holistic view of green driving. Its products, technologies and research initiatives are cruising along both tracks. In this view, the vehicle becomes the center of a vast ecosystem that also includes highways, communication between vehicles and their surroundings, and human propensities.

Semiconductor content in automobiles has been increasing rapidly. Its growth rate is likely to increase even more as carmakers embrace the green revolution.

There is also no lack of pressure to change. The European Union (EU) has set a target of reducing CO_2 emissions to 130g / km by 2015, with a system of penalties of up to €95 ($125) per gram of CO_2 over the limit. The U.S. is likely set a 2016 deadline for carmakers to achieve CAFE (corporate average fuel economy) standards of 34.1 miles per gallon. In China, the government is targeting of 42.2 mpg by 2015.

Ahead of the curve

NXP's enabling products for electric power steering include MR angle sensors that provide a reliable measurement of steering position, and power MOSFETs that help to extend the range of electric cars, and controllers for intra-vehicle communication.

As envisioned by automobile manufacturers, a "partial networking" solution saves energy by keeping selected parts of a vehicle's network active and putting the remaining nodes in a low-power "selective sleep mode." NXP's partial network-enabled System Basis Chips reduce current consumption of the inactive ECUs to 25 µA.

For leading-edge Intelligent Transport Systems, NXP has developed a low-cost, turnkey solution in a compact form factor that combines optimal connectivity and ultra-low power consumption.

Track 1: "Frictionless" components

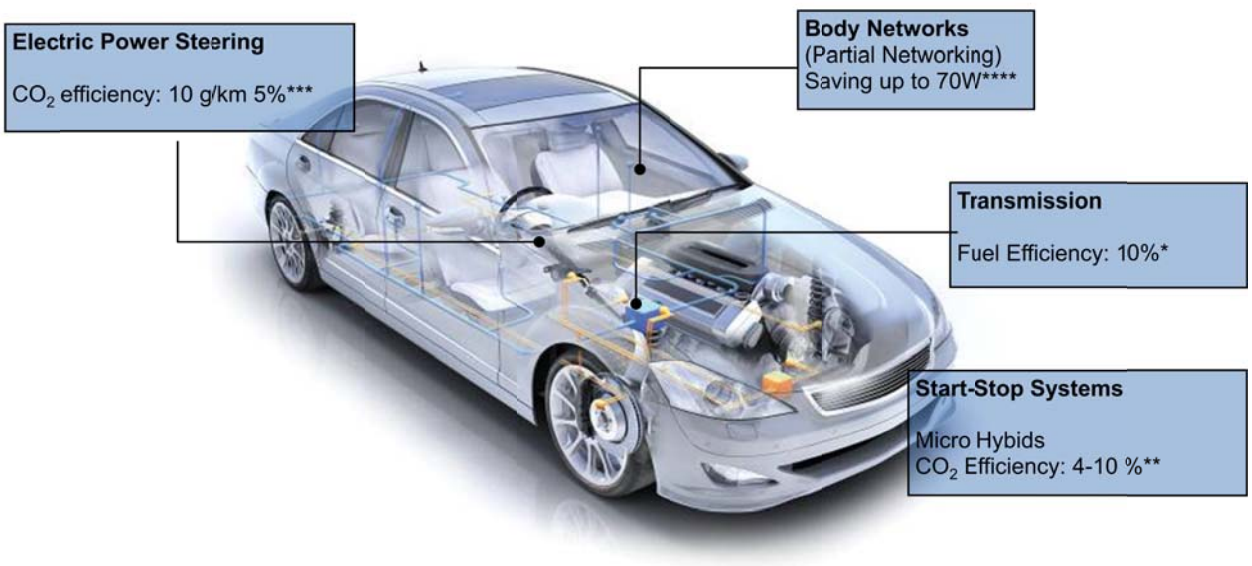
Since internal combustion engines consume hydrocarbons and produce CO_2, it only makes sense to start with the engine – and that's historically been the case. Unfortunately, increased combustion efficiency and catalytic converters can take the industry only so far. Hybrids and electrics have become the stars of the green driving revolution but in a world in which gas and diesel engines still power more than 90% of new cars sold worldwide, it would be foolish to stop innovating traditional vehicles.

It is surprising to see how much fuel efficiency can be added outside the engine. Electric Power Steering (EPS), start-stop systems, dual-clutch transmissions and a category known as body electronics can, when added together, contribute a significant boost in efficiency.

- *Start-stop systems* are already being deployed in hybrids. They are well-named because they stop the engine every time the vehicle comes to a complete standstill and restart it on a variety of cues from the driver. Especially effective in grid-locked city traffic, these systems reduce fuel consumption and CO_2 emissions between 4% and 10%, according to SupplierBusiness.com, a news analysis website for senior executives in the automotive supplier industry. Communication across the power train components is the key technology enabler of start-stop systems. When the ABS speed sensor detects that the vehicle is halted and the gear is not inserted, for example, the engine control unit then stops the engine. Or, when the gear or clutch is inserted and the pedal is pressed, the engine control unit re-starts the engine. NXP provides high-performance transceivers for CAN and FlexRay networks, as well as power MOSFETs for specific functions in the engine, ABS and gear box control units. NXP's MOSFETs and sensors detect the position of the pedals and ABS speed.

- *Electric Power Steering* (EPS) uses an electric motor instead of a belt-driven hydraulic pump that must run continuously, even when the engine is idle and no assistance is needed. By replacing the loss producingsteering linkages of a conventional hydraulic system such as valves and pumps, oil reservoirs, and pressure hoses, EPS systems do more than boosting efficiency. They also pare pounds off the vehicle's weight so it consumes less fuel. Electric Power Steering can save 10 g/km in fuel and CO_2 emissions, according to ZF Lenksysteme GmbH, a leader in automatic steering technology.
  NXP's enabling products include: MR angle sensors that provide a reliable measurement of steering position and torque; power MOSFETs with very low $R_{DSon,}$ which helps to extend the range of electric cars that use EPS; and, FlexRay transceivers that enable fast, fail-safe real-time operation of EPS systems.
- *Dual-clutch transmissions* deliver an uninterrupted power flow between the engine and transmission, which minimizes energy loss during gear shifts. They can upshift, for example, in as little as 8ms, which also enhances the driving experience. But the big win is in efficiency and according to iSuppli they offer as much as 10% energy savings compared to conventional five-speed automatic transmissions. NXP's High Performance Mixed Signal products for dual-clutch transmissions include accurate contactless sensors for optimized shifting. The sensors use MR technology that is insensitive to vibrations. NXP's portfolio and expertise in FlexRay and CAN systems are also ideal for building DCTs.
- *Body electronics* refers to the communications networks that connect hundreds of control and monitoring units to each other – and respond to the driver's commands. These electronic control units (ECUs) operate electric windows, control the engine, brakes, transmission as well as dozens of other functions. Until about 10 years ago, each ECU was controlled by its own wire but as the wiring harness became thicker and thicker, it was replaced by networks that carry information addressed to the particular component that needs to be actuated. The downside of this solution – as realized in today's cars – is that all the ECUs have to be "on" at all times, which results in wasted energy. The solution as envisioned by NXP and other industry leaders is "partial networking," which keeps selected parts of a network active and puts the remaining nodes in a low-power "selective sleep mode." They are immediately awakened to respond to specific, pre-defined messages.
  Combined with other smart NXP products, NXP's partial network-enabled SBCs reduce current consumption of the inactive ECUs to the bare minimum of 25 µA which amounts to a savings of about 70W.

Figure 1 illustrates the energy saving potential of the four technologies just discussed.



In summary, the potential efficiency gains for the systems just mentioned are: Start/stop systems will reduce fuel consumption and CO_2 emissions between 4% and 10%; electric power steering can save 10 g/km in CO_2 emissions; dual-clutch systems deliver 10% energy savings compared to conventional five-speed automatic transmissions; and, partial body networks can save up to 70W.

Although maximizing the efficiency of conventional internal-combustion vehicles delivers the biggest immediate return in energy conservation, electric vehicles have even greater potential. The time needed to charge the battery remains one of the limiting characteristics of hybrids and is even more of a problem for electric vehicles. The answer is charging the battery at higher voltages. Charging at 480 V instead of 110 or 220V would, for example, reduce charging times from as long as overnight to just a matter of hours. The higher the voltage, the faster the charge.

Higher voltages raise safety issues, however, and isolating the high voltage from human beings – and the sensitive electronics in the car – is mission-critical. NXP's ABCD9 process and its EV-HV process are both ideal candidates for doing this job.

Another challenge of high-voltage electric vehicles is optimizing the performance of the battery itself. There are many cells in an automobile's battery pack and if they are not managed effectively the overall performance will be determined by the weakest cell in the chain. NXP is developing technologies that include controllers, sensor systems and high voltage isolation systems that will ensure that the battery operates near its maximum efficiency.

Track 2: Less congestion, less stress, less wasted fuel
The potential of the second track to energy efficiency has not yet been fully discovered but it has the

advantage of being a win-win solution: If a car takes the most fuel-efficient route by avoiding grid-locked areas, for example, the driver gets to his or her destination faster and with less anxiety.

Eco-routing is a combination of technologies that includes cellular, geographic positioning, and on-board computer systems that together identify alternate routes – particularly if the driver has planned a route on a GPS system – to avoid congestion or save energy in some other way such as a shorter route or one that provides the best overall fuel economy. A similar approach is a technology known as connected cruise control technology in which drivers receive speed advice from a traffic control center. Cars can also share information with each other to avoid accidents or align speeds to reduce congestion.

Telematics also includes information sharing inside the vehicle. Electric-powered cars can employ telematics to monitor and diagnose battery health and optimize the battery's state of charge. Still another energy-saving application is the "eco-powertrain," which monitors the landscape ahead and advises the electric power train to optimize its charging and decharging behavior and optimize the use of the range extender if available.

The entire package – intra and inter-vehicle communication – is often referred to as Intelligent Transport Systems (ITS). ISuppli predicts ITS could improve fuel efficiency and reduce CO_2 emissions by 15%.

For this part of the green driving ecosystem, NXP has developed ATOP (Automotive Onboard Unit Platform), a low-cost, turnkey solution in a compact form factor that combines optimal connectivity and ultra-low power consumption.

Closely related to – and dependent on – Intelligent Transportation Systems, are strategies that provide incentives or disincentives for drivers to use less fossil fuel. Large cities such as London are already beginning to restrict vehicle access to their most congested neighborhoods for considerations such as smog control for which a societal cost in terms of heath can be determined. But this go/no-go solution can be improved by the application of Intelligent Transportation System technologies.

Road pricing is a prototypical application. An electronic module consisting of a GPS chip, a secure microcontroller and a radio interface can implement an automatic fare collection system. The module communicates with a toll authority's database information such as vehicle type and traffic patterns. The toll authority's billing system calculates the level of usage of public resource and charges the driver accordingly. The secure microcontroller is included in the module because the module is essentially acting as a cash register.

This approach has already been shown to be remarkably successful. In a road-pricing trial conducted in the Netherlands by NXP and IBM early in 2010, 70% of drivers improved their driving behavior by avoiding rush-hour traffic and using highways instead of local roads. They also experienced a 16% improvement in average cost per kilometer.

A fully implemented system, NXP and IBM calculated a 15% reduction in kilometers driven per year and a 10% reduction in CO2 emissions. (The gains from road pricing initiatives are, by the way, not included in the 15% fuel consumption gains cited above by iSupply for basic ITS.)

Although road pricing might at first glance seem a bit intrusive, it is a much more equitable way to charge for CO_2 emissions. It is, perhaps, the only way a heavily polluting vehicle can be assigned its fair share of environmental damage cost. Road pricing is far superior to charging the same toll to the fuel-efficient hybrid and the 20-year-old gas guzzler.

NXP is also applying its deep application knowledge in automotive radios to eco-engineering. As a founding member of the SPITS (Strategic Platform for ITS) project, NXP is leveraging its expertise in Software Defined Radio) for car-to-car communication to decrease the occurrence of speed-difference-induced traffic jams. The overall objective of SPITS is to define an open, scalable platform for future systems by exploring new techniques in cooperative driving and mobility.

Making a difference

After years in development, the automobile industry is finally fielding technologies that make great strides in reducing the pollution caused by vehicles. Semiconductors play a critical role in maximizing the efficiency of these technologies and, in the case of battery-powered vehicles, assuring their safety. NXP has been involved in these initiatives from the beginning and is continuing to develop innovative solutions that will make green driving a reality.