



## Nissan's Advanced Technologies - PURE DRIVE

### NISSAN COMES FROM BEHIND TO LEAD IN SUSTAINABILITY

Seven years ago, Nissan was widely criticized as an environmental laggard. As archrivals basked in the green spotlight with their hybrids, Nissan had little to show from an R&D pipeline that was only just recovering from years of reduced spending.

The criticism stung. But like a red cape waved before a bull it goaded Nissan engineers into a full-force charge to prove they were not only as good as the competition – but better, way better.

As a result, today's "green playing field" looks quite different. Nissan is now in the front rank of the race to a future of sustainable, zero-emission mobility.

The launch of Nissan Leaf – the first modern, mass-produced all-electric vehicle (EV) – has drawn widespread attention and awards worldwide. But Leaf is only the opening act in long-range plan for a comprehensive suite of sustainable technologies.

Ultimately, Nissan believes electric propulsion is the key to sustainable mobility. But there is still a long way to go before electricity can challenge the dominance of fossil fuels. And the pace of progress will be determined by choices made by millions of consumers around the world.

So the Nissan Green Program – the company's blueprint for environmental progress – charts a long-term holistic strategy: pushing the limits of current technology while moving ambitiously toward an electric future.

### PURE DRIVE: Go Further On Less

Although there may be no "magic bullet," no single breakthrough that could eliminate emissions and end our dependence on oil, there is still vast scope to improve today's internal-combustion engines (ICEs) that effectively use just 20 percent of the energy value in petroleum fuels. Progress may come in small, incremental steps. But small steps and simple solutions are critical to near-term progress, especially in fast-growing emerging markets where customers cannot afford high-cost remedies. Taken together, many steps will amount to a dramatic leap.

In a nutshell, this is the philosophy behind PURE DRIVE, a broad-based effort to perfect the ICE and rethink every aspect of the car, searching for even the tiniest sources of lost momentum, drag and excess weight.

Here are some of the innovations emerging from Nissan's PURE DRIVE pipeline.

#### Continuously variable = robustly green

Engines usually get more attention, but there is plenty of scope for eco progress in the gearbox. Conventional automatic transmissions (ATs) typically waste significant amounts of fuel by selecting gear ratios less-than-efficient for specific road conditions.

Nissan believes the greenest answer is the continuously variable transmission (CVT), which replaces fixed gears with two tapered pulleys linked by a metal belt. The result is smooth acceleration and a much wider range of gear ratios that serve to boost fuel economy.

The CVT concept is not new – Leonardo da Vinci originated it – and Nissan is not the only maker working with it.

But Nissan produces more CVT cars than anyone else – nearly 9 million units since 1992. And Nissan engineers have worked intensively to perfect CVT in the course of developing applications for successively larger engines – from 1.2-liters all the way up to 3.5.

With fewer moving parts, CVT is simpler than AT in principle. But as some early efforts accelerated awkwardly and generated more internal friction than ATs, many took a skeptical view of CVT – particularly motoring journalists who scorn automatic.

All this led several brands to give up on CVT. But Nissan engineers have persevered in overcoming multiple obstacles.

“We never gave up,” says Hirofumi Okahara, the chief powertrain engineer heading Nissan’s CVT team. “We just kept working on it, steadily building our knowledge base from one generation to the next – and our persistence has paid off.”

Consequently, anyone whose opinion of CVTs was formed a decade ago will be surprised how far Nissan has come with its new generation of XTRONIC CVTs, which includes a lightweight version for 1.2 to 1.8-liter engines (introduced in 2010) and a 2.0 to 3.5-liter version, available on 2012 models.

That means Nissan can now offer CVT across its entire lineup. And the first payoff is fuel economy. The latest XTRONIC models get 10 percent better mileage than earlier versions and almost eight percent better than current six-speed ATs.

Fuel efficiency gains have been achieved mainly through reducing friction and increasing the range of gear ratios. In the new 2.0 to 3.5-liter version, friction has been reduced by up to 40 percent compared to the current model, bringing it down to levels comparable to current 6-speed ATs.

A number of key design breakthroughs made all this possible. The adoption of a more compact oil pump was achieved by reducing oil leak and reducing necessary oil pressure resulted from the interface increase between the pulleys and the belt. This, plus the use of specially formulated low viscosity oil, has reduced friction.

A new and stronger belt, and a thinner pulley axle, meanwhile allowed Nissan engineers to extend the range of gear ratios. The result is a new benchmark in gear ratio range: 7.0 for CVTs for 2.0-liter-plus vehicles around the world..

Even better, CVT no longer means sacrificing driving pleasure for the sake of fuel economy. With a wider range of gear ratios and Adaptive Shift Control that offers more than 1,000 shift patterns in sporty, normal and city modes, XTRONIC lets you choose a driving experience to suit the road and your mood.

What critics used to call “rubber-band acceleration” is now history.

Today’s Nissan CVTs are also much more robust and durable than earlier versions – even in sub-zero temperatures. Feedback from the largest fleet of CVTs on the road has allowed engineers to continually improve performance. So Nissan CVTs now merit the description “low maintenance.”

What’s more, CVT is emerging as a keystone technology that enables other innovations. Nissan’s new hybrid and its ultra-efficient, supercharged three-cylinder DIG-S engine both leverage the benefits of CVT. And so do Nissan’s new Stop / Start System and ECO Mode functions.

Best of all, CVTs are now competitive with six-speed AT in terms of cost.

These advances have paved the way for Nissan to extend CVT to a wider range of models and markets. Through three generations since 1992, Nissan has progressively introduced two ranges of CVT for use with engines of all sizes: 1.2 to 1.8-liter; and 2.0 to 3.5-liter.

In 2010, Nissan sold nearly 1.7 million CVT-equipped vehicles worldwide – nearly 40 percent of global unit sales.

With the launch of the new generation XTRONIC for 2.0 to 3.5-liter engine vehicles, Nissan will continue to expand the use of CVT in emerging markets, where they represent appropriate technology: an affordable solution to rapidly growing fuel consumption and CO<sub>2</sub> emissions.

“We think *now* is the time for people to reconsider their opinions of CVT,” Okahara says. “The technology is fully mature. We already have a 10 percent edge on conventional automatic in terms of fuel economy and nine percent in CO<sub>2</sub> emissions – and we’re not done yet.

“From here, the biggest obstacle ahead is consumer perception of CVT. We need people to see for themselves how robust and durable it is – and how much driving pleasure it delivers.

“What we really hope people will recognize, though, is that choosing CVT is a statement of eco-consciousness *and* a smart investment. With CVT, unlike hybrid, you don’t pay a huge premium to make a green statement. What you save on fuel is yours to keep.”

## **We do hybrids, too – and *better***

“We must have a tougher job than any other hybrid team in the industry,” says Mitsunobu Fukuda, a senior powertrain engineer at NATC. “Because our CEO, Carlos Ghosn, used to be known as skeptical about the value proposition of hybrids we had to make a really compelling case that we could deliver value to customers to get him to validate a hybrid program.

In 2004, as a stopgap measure, Nissan licensed hybrid technology from Toyota for use in certain markets.

“It was a bit of a blow to our pride, but that was the right thing to do under the circumstances,” Fukuda says. “Instead of rushing out a ‘copy-cat’ hybrid we wanted to take the time to develop our own hybrid, one that is clearly different – and better. I think we’ve managed to do that.”

The first generation of hybrids aimed to eke maximum mileage out of a compact car – and they succeeded in a sense. But as the average family cannot recoup the extra purchase cost from fuel savings – even at historically high fuel prices – hybrids have been more a statement of environmental consciousness than a smart investment. What’s more, the high cost of hybrid limits its usefulness in the emerging markets where growth is concentrated.

Mindful of these limitations, the Nissan team focused on market segments where hybrid offers a more solid value proposition.

Buyers of larger vehicles can better afford the higher cost, and the green halo around hybrid dispels any stigma involved in buying a larger vehicle. Increased fuel economy also helps bring larger vehicles in line with fleet-average requirements.

But the Nissan team’s real ambition was to offer customers the opportunity to recoup any extra purchase cost with fuel savings. And they have come close.

Other hybrids typically comprise a fairly large gasoline engine, two electric motors, a clever if complex transmission and a nickel-metal hydride battery.

Nissan's new hybrid, by contrast, includes a smaller but supercharged 2.5-liter gasoline engine mated with a compact CVT package (that incorporates a single motor and two clutches) plus a smaller lithium-ion battery. Equipped with advanced electronic control, it matches the performance of a full throated 3.5-liter engine but with vastly improved fuel economy – and without drastically raising the sticker price.

Several key innovations give the new system an edge over competitors.

The “one motor, two clutch” configuration is an ingeniously simple solution to the power mismatch between gasoline engine and electric motor. Combining these functions in a variant of a mass-produced CVT minimizes the need for costly, exotic technology.

Better yet, as the system comprises a very compact package no trunk or cabin space is sacrificed for batteries. What's more, as it is not significantly bigger than an equivalent ICE it doesn't require a special-purpose body. As a result, Nissan's hybrid can be offered as an option in a variety of models.

The new hybrid will make its debut in 2013 with models for North America and Japan. Details have yet to be announced, but the Nissan team is determined to deliver a hybrid with fuel economy that comes close to justifying the extra purchase cost. Watch to see how they do.

### **The bottom line on fuel economy and emissions**

Combine CVT with hybrid and/or smaller but still powerful ultra-efficient engines. Stop the sin of idling. Help drivers learn new fuel-efficient habits. Each of these steps will take us closer to a zero-emission future.

Technically, Nissan has the know-how – plus the determination needed to get the job done.

In the end, though, it's up to millions of individual customers around the world to choose. If people demand near-term environmental progress, Nissan can deliver it today.

Ultimately, Nissan's sights are set far down the road to a day when sustainable mobility is something everyone takes for granted.

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