

electric & hybrid

vehicle technology international

JANUARY 2017

THE

GREAT

EV

We investigate EV range claims and discover how the all-new WLTP standard will shake up development of battery vehicles forever

LIE?

TOP CAT

The launch of the I-Pace SUV is not just big news for Jaguar, it's a massive momentum shift for the EV movement

ON A MISSION

It's not easy chasing down Tesla, but that's what Michael Steiner, Porsche's R&D guru, is aiming for as launch of the Mission E nears

RACE READY

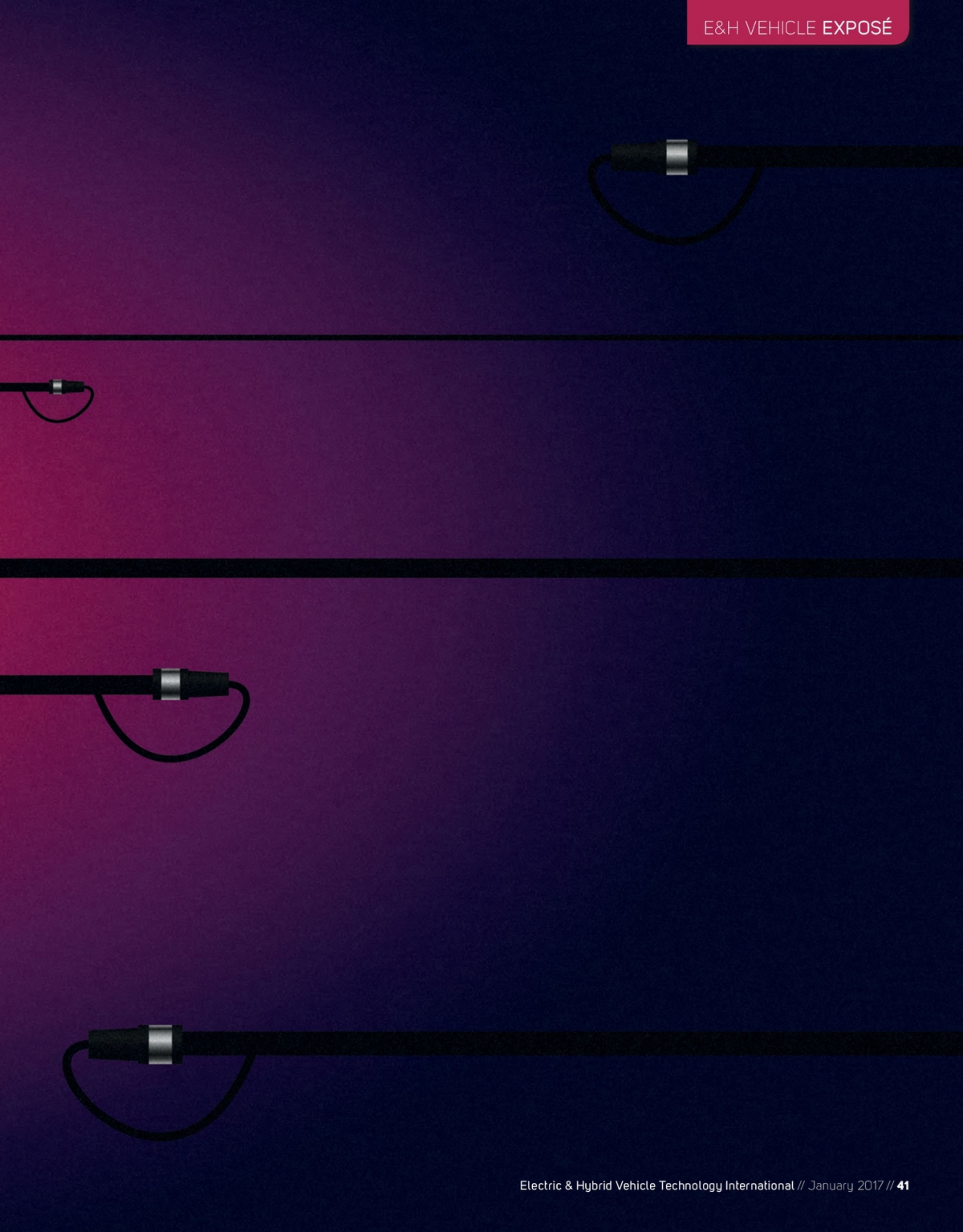
As JLR and Audi join Formula E, will the electric racing series become the number one motorsport competition?

TRUE

LIES

E&H Vehicle investigates the huge gulf between official EV ranges and real-world figures, and looks at how the incoming WLTP standard could help paint a more accurate picture

WORDS: LEM BINGLEY



At the Paris Motor Show in September 2016, Renault-Nissan chairman and CEO Carlos Ghosn had barely sprung the surprise of a new 400km (248 miles) edition of the Renault Zoe before conceding that the improved electric car could not actually cover that distance. "It is 400km NEDC, which is the official standard. It's 300km (186 miles) in real life," Ghosn admitted.

NEDC – the New European Driving Cycle – is the test that all manufacturers must use to establish the official range of battery EVs sold in Europe. Exactly the same test is used to derive fuel economy and CO₂ figures for conventional IC engined cars – and there are steadily growing gaps between test results and typical owner experiences in the real world.

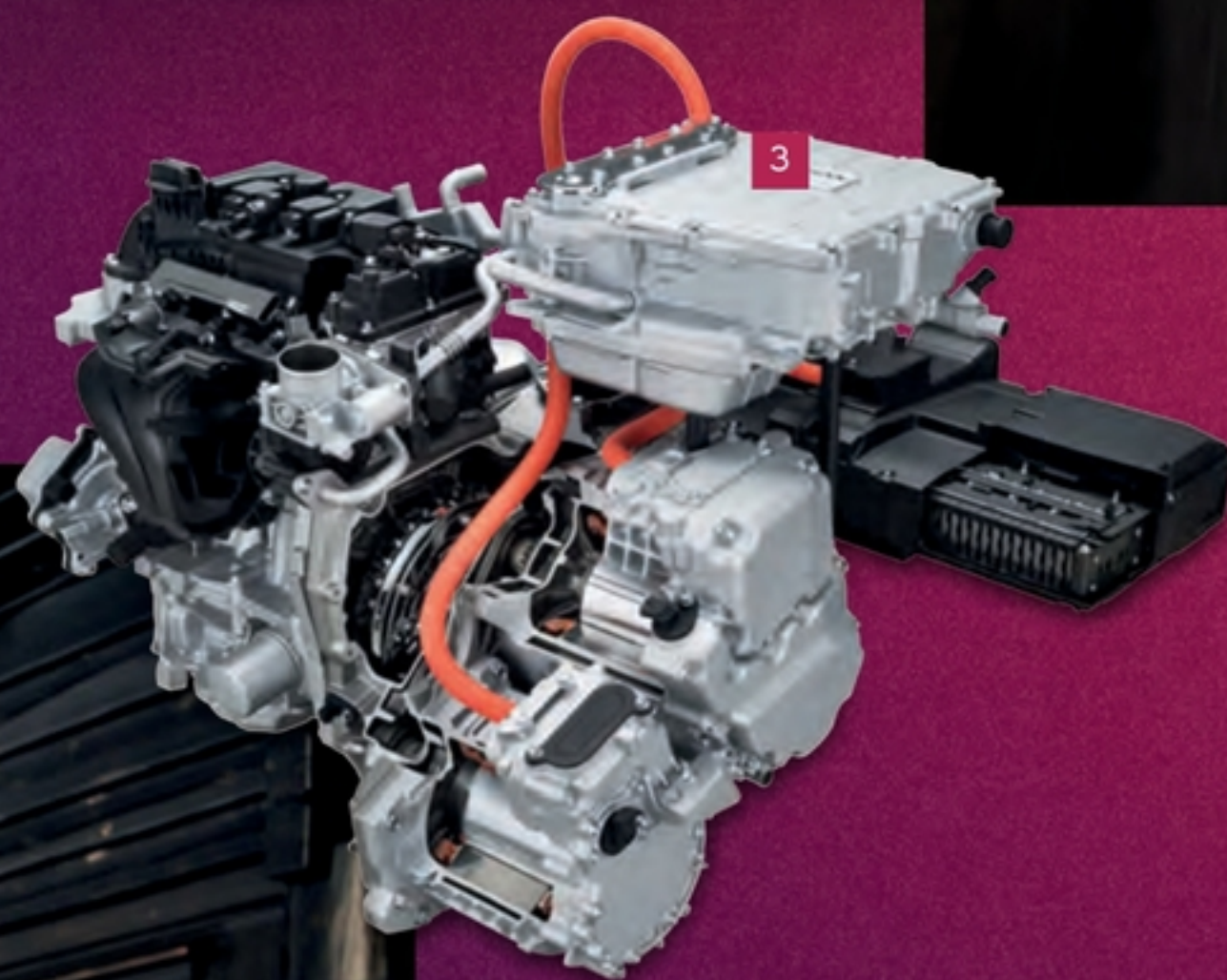
A hard-hitting study published in September 2015 by consultant Element Energy and the International Council on Clean Transportation (ICCT) found the gulf between NEDC figures and real-world CO₂ emissions for new cars increased from 10% to about 35% between 2002 and 2014. Ghosn's remarks, plus real-world data collected by the Spritmonitor website in Germany, suggest EVs suffer to much the same extent.

No matter which way one looks at it, it's hard to imagine another area of commerce in which official yardsticks could become so stretched. Imagine if filling stations could charge per liter for every 750ml, or if 4kg bags of potatoes came up a kilo short. But that is exactly what European electric vehicle buyers face at present.

Further confusion arises at the global scale. EV buyers in North America, for example, are offered completely different official range measurements, based on test procedures set by the US EPA.



1. Renault estimates that the revised Zoe, fitted with the new Z.E.40 battery, has a real-world range of between 299km (186 miles) in temperate conditions and 199km (124 miles) in more extreme cold conditions



2. The Leaf 30kWh upgrade model delivers up to 249km (155 miles) of driving range on a single charge, claims Nissan

3. Nissan's e-Power innovation draws on the EV tech created for the Leaf. Unlike application in the all-electric Leaf, however, e-Power adds a small IC engine to charge the high-output battery when necessary, thereby eliminating the need for an external charger





"The current test is entirely obsolete and no longer serves any useful purpose. And if it is poor or obsolete for conventional vehicles, it has always been useless for electric vehicles"

Greg Archer, director of clean vehicles, Transport & Environment

4. The pioneering Tesla Model S. The 90D model has a quoted driving range of 557km (346 miles) under NEDC, whereas under EPA it is rated at 473km (294 miles)

4



5. The new e-Golf's average driving range has increased by around 50% to around 200km (124 miles), says VW. Driving range in the NEDC is up to 300km (186 miles)

5

The gap between NEDC and EPA figures can be large, but unpredictably so. For example, a customer considering a Tesla Model S 90D will see a quoted range of 557km (346 miles) under NEDC, whereas the same model is rated at 473km (294 miles) under EPA – a 15% reduction. And that drop provides no guide to the shortfall experienced by a 30kWh Nissan Leaf, which is rated at 249km (155 miles)

under NEDC and 172km (107 miles) by EPA. That's a whopping 31% fall.

These gulfs arise because NEDC and EPA measure different things in different ways, and both are assessed under lab conditions. In turn, each is a world away from the comparative chaos of real roads, real drivers and real traffic.

WLTP takeover

The 'New' in NEDC is a misnomer. The test procedure dates back to the 1970s and hasn't been updated in almost 20 years. Greg Archer, director of clean vehicles at Brussels-based lobby group Transport & Environment, is scathing in his criticism. "The current test is entirely obsolete and no longer serves any useful purpose," he says. "And if it is poor

or obsolete for conventional vehicles, it has always been useless for electric vehicles. It is a complete distortion of reality."

The NEDC's days are numbered, thankfully. It will be replaced next year in Europe by a new protocol, the Worldwide Harmonized Light Vehicles Test Procedure (WLTP), which will employ a new test cycle, the WLTC.

WLTC is tougher than NEDC, but there will still be a gap between test CO₂ figures and real-world results of about 23%, likely to grow to 27% by 2030, the ICCT predicts. The move to WLTC is also expected to close some of the gap between Europe and North America, although the US system will still produce lower EV ranges more in line with the real world.

One major reason for this is that the US tests consider the impact of heating and air-conditioning, which can have a very distinct effect on an EV's range. "That will still be out of scope for WLTP," observes Phil Stones, chief engineer for powertrains at UK-based vehicle testing specialist Millbrook.

"There have been discussions for a number of years about creating a test called MAC – mobile air conditioning – however in Europe that hasn't been instigated," he says. "The federal test uses a five-cycle procedure and then takes a weighted average over all those cycles to get a declared figure. In Europe, we don't. So an EV doesn't have to do a test with air-con on."

There will also be a confusing period of transition in Europe between September 2017 and December 2019 when NEDC will be used for run-out vehicles while new models must quote stricter WLTP figures. A label to make sense of this overlap remains to be designed, just as many other aspects of WLTP are still being hammered out.

"A lot of it is still in draft at this time; still being agreed in Brussels," outlines Stones. "It's a very, very tight timeframe."

Creative freedom

While the nature of NEDC accounts for much of the gap between official and real-world results, manufacturers have deepened the problem through their creative interpretation of the rules and occasionally, as in the case of VW and the Dieselgate scandal, by outright cheating.

Before the NEDC lab tests can be conducted, the car first needs to be calibrated for road

friction and aerodynamic drag. As a report published in March 2013 by Transport & Environment notes, "When the road load test procedures were drafted 30 years ago, no-one expected car makers to adjust the brakes, pump up the tires, and tape up all the cracks around the doors and windows to reduce the air and rolling resistance."

Similarly, during the actual NEDC testing phase, vehicle manufacturers can improve results through a variety of tweaks, such as pre-charging the battery to reduce the parasitic load of the alternator.

Millbrook's Stones says type approval inspectors generally do a good job checking that the rules are being obeyed, but that they can't stop things that aren't forbidden.

"There are tolerances on everything, but you don't have to go down the middle of those tolerances," he says. "If you were to go to the preferred end of those tolerances, then that's



WHAT THE INDUSTRY SAYS



GORDON MURRAY
CEO, GORDON
MURRAY DESIGN

Range anxiety is one of the biggest issues, and I would back a complete overhaul of the way we measure energy consumption – whatever the powertrain. The difference with petrol and diesel cars with real-world consumption – and therefore emissions – and actual consumption, is about 26%, and that's because every manufacturer plays the game. For EVs and particularly hybrids, it's ridiculous how they are tested. Compared with the range you can actually achieve, it's a phenomenal difference – and that's because they are tested with no loads and in ideal conditions. I think it's about time the industry owned up and re-wrote all the tests because the public don't know these things are going on.



RALF HANNAPPEL
DIRECTOR FOR EUROPEAN
ELECTRIFICATION, GM

We know that range anxiety is the biggest issue and we have anticipated that. This is a legislative thing because we have test cycles that we drive the cars on – about 500km (310 miles) in the NEDC and that will change when we go over to the WLTP, which is closer to reality. We have driven this car [the Ampera-e] on the new test cycle to give a preliminary range figure and we have estimated a range of more than 380km (236 miles), which is very realistic. If you look at the test cycles [NEDC], the car is driven on a certain speed range that the typical customer might not drive, so it's good for comparison, but for real life it's different. To make it more realistic, a more realistic test cycle is needed.



GERALD KILLMANN
HEAD OF POWERTRAIN,
TOYOTA EUROPE

There are some circumstances that are valid for all auto makers, such as the reference of fuel consumption/energy consumption/range for any vehicle is done in a standardized cycle for fairness. This cycle differs from actual driving conditions. Depending on the actual driving style, you may get close to that range, or even better in some cases, or worse in others. One thing that is important to understand is that for any vehicle, energy consumption is being optimized constantly by all OEMs. There is a change coming to the test cycles from NEDC to WLTP, which will change the driving patterns, and I believe in the future that the difference in real-world driving and the cycle will be far less.



1. A lot of legislation still needs to be completed for electric vehicles, including standardized charging as well as the introduction of fairer test cycles that better represent real-world driving and ownership

legal. So, would I say that happens a lot? Yes. It's a competitive world."

It seems likely that EV makers will have used all the applicable tricks developed for IC-engined cars. "I don't have any direct evidence, but I see no reason why they wouldn't," confirms Archer. "Deploying various optimization strategies is what the manufacturers do. They used to deny it until the European Commission started to work out how to correlate between NEDC and WLTP, and suddenly they wanted to gain credit for all the flexibilities that are in the current test but aren't in the future one. All of a sudden, all the evidence came out."

More rigid rules provide another reason why EPA range figures tend to be lower. "There is less gaming done in the USA because the test procedures are more fully defined," explains Archer. "The other big difference is the system of approving vehicles."



GILLES LE BORGNE

EXECUTIVE VICE PRESIDENT,
RESEARCH AND DEVELOPMENT, PSA

By the time of the next Paris Motor Show [2018] this issue won't be a problem. We're working with a new, third generation of lithium-ion batteries for our forthcoming BEVs – a combination of four B-segment and entry-level C-segment cars by 2021 – and they will be capable of doing 450km (280 miles). This new generation of lithium-ion is really outstanding in terms of performance. Today, everyone's BEV range readings are based on the current NEDC cycle, where you lose around one-third of the real range. But the forthcoming WLTP cycle is very close to real life. It's not exactly like real life, but it's much closer than NEDC, so the gap between real-world range and lab range will decrease.



MICHAEL WINKLER

HEAD OF POWERTRAIN,
HYUNDAI-KIA

The key item is that with electric vehicles, you have to offer the customer a vehicle that fulfills their daily needs. The biggest need is to be able to get to work and back, and have enough range left in reserve. Even though we can achieve driving ranges in the region of 300km (186 miles), which is more than enough for the daily needs of a driver, the fear the customer has of range anxiety, we have to take seriously. The move toward WLTP should help with that.



JÜRGEN SCHENK

DIRECTOR OF E-DRIVE SYSTEM
INTEGRATION, DAIMLER

No testing method – and that includes WLTP – will be able to provide a single realistic figure. This would mean that any driver, driving the same vehicle, anywhere in the world, in real life would always get the measured consumption, despite different climate zones, driving styles, loads and route profiles. To achieve a more reliable range indication – before and during the trip – the driver should enter the destination into the navigation system. This allows the car's software to adjust its battery range prediction according to the topography, factoring in climbs and opportunities for regen, as well as average speeds and traffic conditions along the chosen route.

In the USA, the initial approval is done by self-certification, but the US EPA then actually checks a sample of vehicles. And if they find disparities, they impose really punitive penalties." In 2014, Hyundai-Kia agreed to pay US\$350m including a US\$100m fine over inflated mileage claims, and other makers have faced similar costs. "Dieselgate was particularly egregious and that's why they've thrown the book at VW," adds Archer.

Similar processes to beef up type approval are being debated by the European Parliament.

"Our expectation is for a vote in January," continues Archer. "We could move toward a system whereby member states are doing the approvals but then there is checking by the European Commission or other third parties on how vehicles are actually performing on the road, and ensuring that they meet durability requirements, and so on. There are questions about how those tests should be done, but the current thinking is that we should move away from laboratory testing to on-road testing."

Emissions Analytics (EA) specializes in on-road testing and has conducted thousands of real-world tests to determine independent figures for fuel economy and emissions. It says it has created a test protocol that produces



1. Established in 2011, Emissions Analytics helps provide accurate fuel economy and driving range data for passenger cars. It has also grown to include the measurement of tailpipe emissions of CO, CO₂, NO and PM

"In the USA, the initial approval is done by self-certification, but the US EPA then actually checks a sample of vehicles. And if they find disparities, they impose really punitive penalties"

Greg Archer, director of clean vehicles, Transport & Environment

THE PROBLEM WITH PLUG-INS

Today's European range figures for EVs are assessed using the NEDC test cycle. "We drive the EV over repeated cycles on a dyno until the vehicle says 'stop please', or it can't maintain 50km/h (31mph)," explains Millbrook's Phil Stones.

"The test is done at 20°C, with no heating or air-con, and it's a very low-energy cycle. So it's kind of as good as you're going to get in terms of range."

While the figure that emerges may be unrealistic, it has the benefit of clarity. When it comes to plug-in hybrids, however, the situation becomes more murky. When a car can be driven on electricity alone, on fuel alone, or using an arbitrary mixture of

the two, how do you arrive at a single figure for its performance?

Plug-ins are tested using repeated cycles to determine the electric-only range, followed by a fuel consumption test with the exhausted battery. The two sets of data are then merged using a weighting factor that reflects how often the typical owner is expected to drive on electricity. This calculation explains how a heavy seven-seat SUV like the

Volvo XC90 Twin Engine can achieve an official CO₂ rating of 49g/km.

"The assumption is that the car drives on its battery 70% of the time," says Transport & Environment's Greg Archer. "But that certainly isn't what's being achieved at present. Plug-in hybrids in the Netherlands are being driven on battery about 35% of the time."

Archer adds that company car drivers who are allowed to claim fuel expenses, but not electricity costs, are in fact being incentivized not to plug in.

The situation has implications for policy in several areas, from CO₂ taxation to charging infrastructure. "As the range offered by battery EVs improves, they will have less need for recharging points," Archer observes. "But you will need those recharging points for plug-in hybrids, so that they can run on batteries more of the time. If you don't achieve that, then you're just carrying around a heavy battery in a not-very-efficient hybrid application."



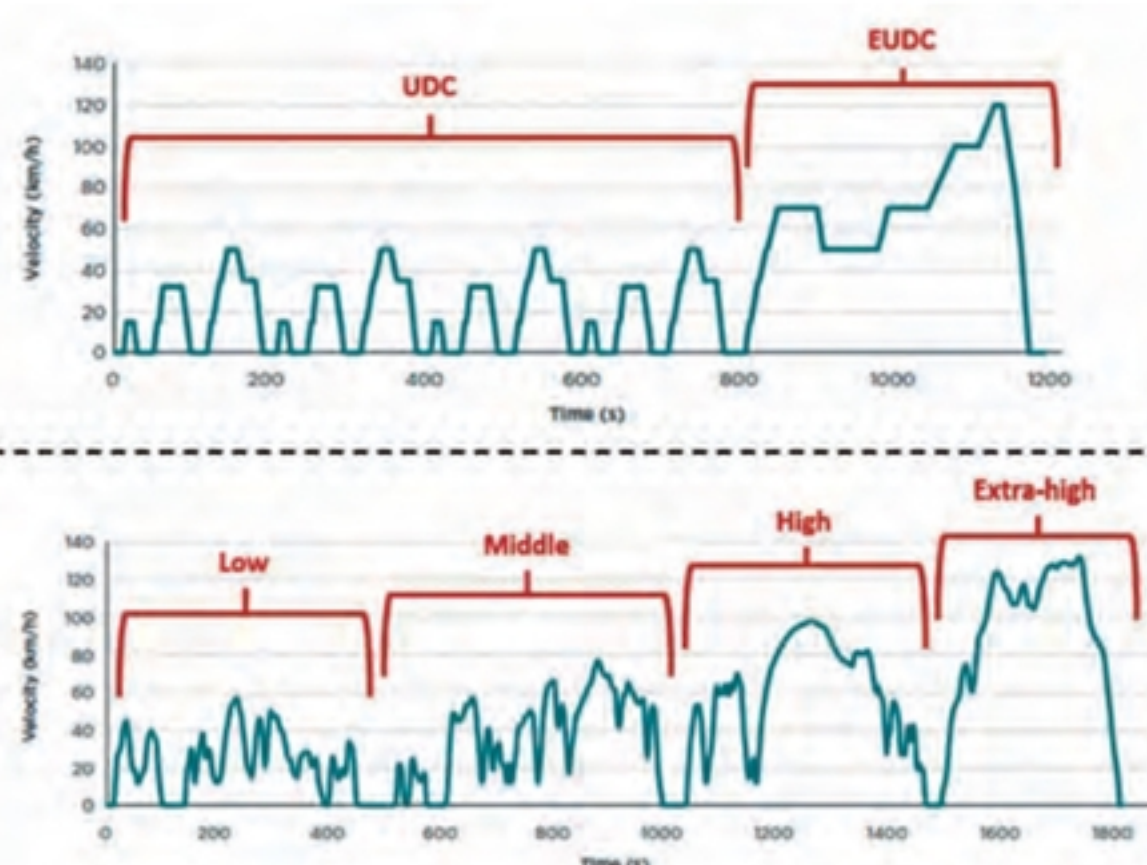
1

2

"I think EVs will have even more exaggerated differences between laboratory and the real world"

Nick Molden, founder and chief executive, Emissions Analytics

3



1 and 2. The Bolt EV, which is due to go into production by the end of 2016, will offer more than 320km (200 miles) of range on a full charge, claims Chevrolet and GM

3. A closer look at the NEDC and WLTC cycles

repeatable results despite the variability of real roads. "The first stage is: keep as many things constant as you can," says EA founder and chief executive Nick Molden.

"We have drivers who are trained to drive the cars in the same way; we always set up the car in the same way, including the amount of weight in the vehicle. The second stage is that the test has to fall within some fairly tight parameters to be considered valid."

If traffic flow or temperature strays too far from the 'norm', the test has to be repeated. The next stage is statistical normalization in order to adjust for whatever deviations from the average were observed during the test.

The final leveller is time – an EA test runs for three and a half hours, whereas NEDC lasts just 20 minutes and WLTP takes 30 minutes.

EA is still at the experimental stage when it comes to testing EV performance in the real world, but it has assessed several models including the Tesla Model S and Chevrolet Bolt. The company measures the net electrical charge used second-by-second over its usual test route, then converts the energy used to a mile-per-gallon-equivalent (MPGe) number, as well as miles per kilowatt-hour.

"If there's one reason to get out of the lab, it's that you need to take EVs up and down hills," adds Molden. "How much does it eat into the battery when you're going up a steep hill, and how much does it recapture going down the hill? Each technology is different. I think EVs will have even more exaggerated differences between laboratory and the real world because of factors like these."

Indeed, Molden argues that advances in mobile testing mean the role of lab testing ought to be questioned in general – and perhaps even assigned to the scrap heap. "There's a lot of habit and vested interest in maintaining a laboratory system," he notes. "It is very accurate, but if it's very accurately measuring the wrong thing, that's not actually helping anyone." □