

# Schrödinger's Car

*The plug-in hybrid conundrum*

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EPUK Conference, virtual

19 November 2020

## Allow Independent Road-testing (AIR)'s core mission

*'To help reduce the negative impacts of **vehicle emissions** in the short and long term.'*

### *Implementation commenced:*

1. Initial focus is to enable NO<sub>x</sub> solutions for today and into the future
2. Comparative, realistic and repeatable CO<sub>2</sub> data
3. Cabin air quality and health exposure ratings that can be trusted

# The AIR Index ratings for vans

Make	Model	Year	Fuel Type	Euro Standard	AIR Index NO <sub>x</sub> Rating	AIR Index CO <sub>2</sub> Rating
Volkswagen	Crafter CR35 LWB High Roof 2.0	2019	Diesel	Euro 6	A	E
Peugeot	Partner Asphalt 1.6	2019	Diesel	Euro 6	A	C
Volkswagen	Transporter T30 Highline TDI Bluemotion 2.0	2018	Diesel	Euro 6	B	D
Mercedes	Vito CDI 114 LWB 2.1	2017	Diesel	Euro 6	B	D
Volkswagen	Caddy C20 Highline TDI 2.0	2018	Diesel	Euro 6	C	C
Ford	Transit Custom 2.0	2018	Diesel	Euro 6	C	D
Mercedes	Vito CDI 111 LWB 1.6 (post-recall)	2017	Diesel	Euro 6	<i>D</i>	<i>D</i>
Vauxhall/ Opel	Vivaro CDTI 2900 1.6	2019	Diesel	Euro 6	D	D
Citroen	Relay L3h2 Enterprise BlueHDi 2.0	2018	Diesel	Euro 6	D	E
Mercedes	Citan 109 Dualiner 1.5	2019	Diesel	Euro 6	E	C

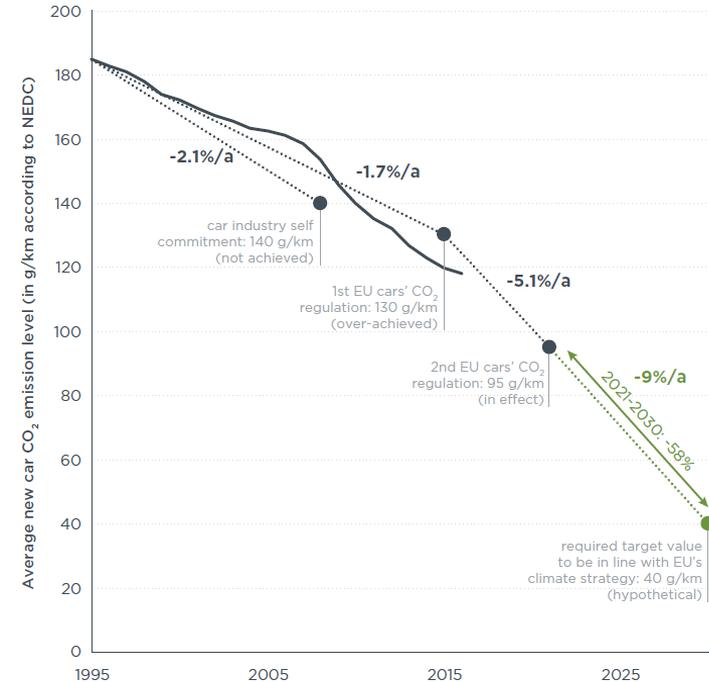
# The AIR Index ratings for latest cars



Make	Model	Year	Fuel Type	Euro Standard	AIR Index NO <sub>x</sub> Rating	AIR Index CO <sub>2</sub> Rating
Renault	Clio 1.5 90PS	2013	Diesel	Euro 6	E	B
Renault	Clio 1.5 90PS	2018	Diesel	Euro 6	B	B
Renault	Clio 1.0 100PS	2019	Gasoline	Euro 6	A	C
Kia	Sportage 1.6 136PS MHEV	2020	Diesel	Euro 6	A	C
Kia	Sportage 1.6 116PS	2019	Diesel	Euro 6	A	C
Kia	Sportage 1.6 132PS	2020	Gasoline	Euro 6	A	D
Ford	Kuga 2.0 150PS	2016	Diesel	Euro 6	D	C
Ford	Kuga 2.0 150PS	2019	Diesel	Euro 6	C	C

# Stretching carbon dioxide reduction targets

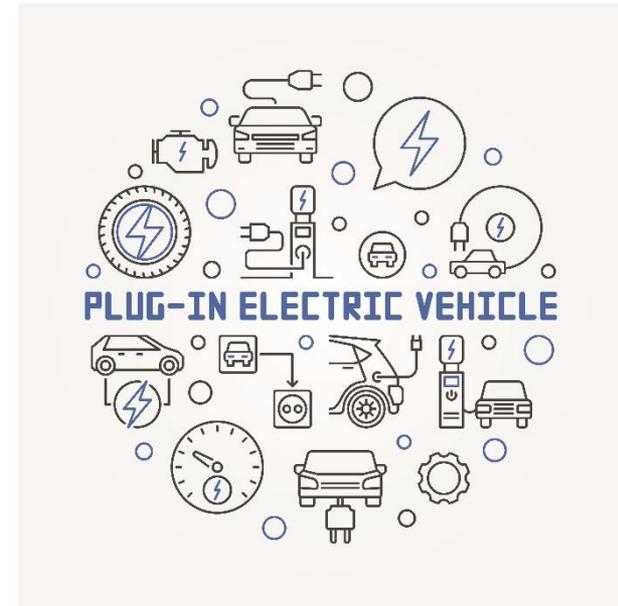
- Fleet average CO<sub>2</sub> 95g/km 2021 target
- CO<sub>2</sub> actually increased after Dieselgate
- Future 37.5% reduction even tougher
- But gap has closed rapidly in 2020
- Due to BEVs and PHEVs
- Are the reductions real and robust?



Source: ICCT

# Origin of plug-in hybrids

- Positioned as the “best of both worlds”
- Much of efficiency of BEVs without the range anxiety
- Most journeys are <5km so can mostly be electric
- No utility compromise
- Much smaller batteries
- Bigger CO<sub>2</sub> reduction with battery material scarcity



# Best of both worlds – typical advertising

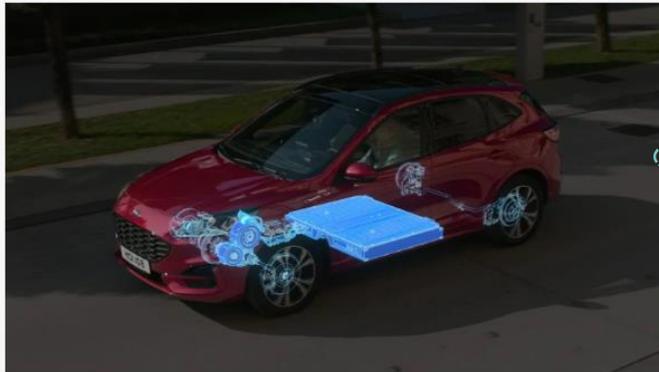
Explore **FORD**

Electric & Hybrid

View the range

Animation

In Hybrid Animation



## Zero emissions and surprising range

Plug-in Hybrid Vehicles (PHEV) have all the functionality of full Hybrid technology, with the added advantage that they can be charged from an external electricity supply. The larger capacity of the battery makes them capable of zero-emissions while driving for ranges of up to 35miles<sup>†</sup>, with the ability to switch to Hybrid mode to conserve battery life and to petrol or diesel-only for longer journeys.

# The issue: Schrödinger's Car

- PHEVs are both good and bad until they driven
- Performance is not mainly inherent in the vehicle
- Instead, it depends primarily on driver behaviour
- Unlike traditional powertrains
- Traditional labelling and type approval values are unsuitable
- For ICEs, CO<sub>2</sub> in urban tends to be a third higher than on the motorway
- For PHEVs, CO<sub>2</sub> ranges from near-zero to higher than ICE equivalent



# Real-world test results from 37 PHEVs



g/km	EQUA Index real-world CO <sub>2</sub> (g/km), zero battery/charge-sustaining mode			Official CO <sub>2</sub>	Variance
	Urban	Extra-urban	Combined	NEDC/WLTP combined	EQUA vs Official (%)
Europe	186.0	178.7	182.1	58.0	+214%
United States	176.9	153.2	167.1	75.5 <sup>2</sup>	+121%
<b>Average</b>	<b>181.5</b>	<b>166.0</b>	<b>174.6</b>	<b>66.8</b>	<b>+161%</b>

- Engine-only mode 2-3 times the certification values
- Real-world CO<sub>2</sub> emissions as high as 299g/km in urban driving without charging
- Virtually zero emissions with short journeys and charging

# Lifecycle emissions – share on battery is crucial

- PHEVs are worse than ICEs if never charged up
- But better than BEVs if always charged up
- WLTP implies 73% of miles on battery vs perhaps 37% in reality

Alternative powertrains	Tailpipe CO <sub>2</sub> (g/km)	Lifecycle CO <sub>2</sub> (g/km)	% of distance that must be travelled on battery for PHEV to be equivalent to alternative powertrain
<i>Gasoline PHEV</i>	<i>0 (all battery running) – 182 (no battery)</i>	41-223	
Gasoline ICE	194	223	0%
Diesel ICE	171	200	13%
Gasoline FHEV	127	158	36%
BEV – cleaning grid	0	93	71%
BEV – zero CO <sub>2</sub> grid	0	50	95%
PHEV WLTP label <sup>4</sup>	50	91	73%

# Market distortion

- Crucial threshold of <math>50\text{g}/\text{km}</math> to be classed “ultra low emissions vehicle”
- Retail subsidy, but only if range is >70 miles
- WLTP underestimates real-world emissions for fleet average emissions calculations
- Exaggerated further by supercredits for next three years
- For company cars, benefit in kind difference: ~42% for diesel vs ~14% for PHEV
- Vehicle Excise Duty first year : £870 (175g/km diesel) vs £0 for PHEV

# Labelling problem



**Mitsubishi Outlander PHEV**

From £35,815

The revolutionary Plug-in Hybrid SUV, perfect for families and businesses alike.

 **ULTRA-LOW CO2 EMISSIONS: 46G/KM (WLTP)**  **28 MILES EV RANGE (WLTP)**  **LOW RUNNING COST**  **ADVANCED 4WD TECHNOLOGY**

**BOOK A TEST DRIVE**

MITSUBISHI

The advertisement features a background image of a Mitsubishi Outlander PHEV driving on a dirt road at dusk. A dashed blue oval highlights the first two features: 'ULTRA-LOW CO2 EMISSIONS: 46G/KM (WLTP)' and '28 MILES EV RANGE (WLTP)'. The car's headlights are on, and the Mitsubishi logo is visible on the front grille.

# Solution?

- Show electric-only range and empty-battery CO<sub>2</sub> on label
- Base taxes and subsidies on real-world emissions
- Incentive for owners to drive on battery, penalty on engine
- Calculation of fleet average CO<sub>2</sub> on actual share of driving on battery

# Conclusion

- Not the best of both worlds, despite the advertising
  - Better than BEVs AND worse than ICEs!
  - Market distorted by regulation and taxation
  - New approach to labelling required
  - Consumers need appropriate incentives
- Without changes, PHEVs are too high risk



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