RAC Foundation

The Green Charge

Analysis of energy and CO_2 emissions data from the 2011 RAC Future Car Challenge

Dr Ricardo Martìnez-Botas
Reader in Turbomachinery, Imperial College London

28 March 2012

Imperial College London

Imperial College London

Contents

1. Introduction
2. Energy consumption
3. CO_2 emissions
4. Costs
5. Driving style
6. Conclusions

Imperial College London

Future Car Challenge Participants

Entries	Manufacturer Entry	Private Entry	Total	Measured
EV (Electric Vehicle)	17	20	37	**34**
PHEV/E-REV (Plug-In Hybrid/Extended-Range EV)	10	1	11	**4**
HEV (Hybrid Electric Vehicle)	3	1	4	**4**
HFCEV (Hydrogen Fuel Cell Electric Vehicle)	1	0	1	**0**
ICE vehicle (Internal-Combustion Engine Vehicle)	5	4	9	**7**
TOTAL ENTRIES	**36**	**26**	**62**	**49**

Imperial College London

2010 and 2011 Participants Comparison

Power train	Number of vehicles in FCC 2010 (measured)		Number of vehicles in FCC 2011 (measured)	
EVs	19	**(16)**	37	**(34)**
HEVs	19	**(18)**	4	**(4)**
E-REVs/PHEVs	4	**(1)**	11	**(4)**
HFCVs	3	**(1)**	1	**(0)**
ICE vehicles (≤110 gCO_2/km)	16	**(14)**	9	**(7)**
Total	61	**(50)**	62	**(49)**

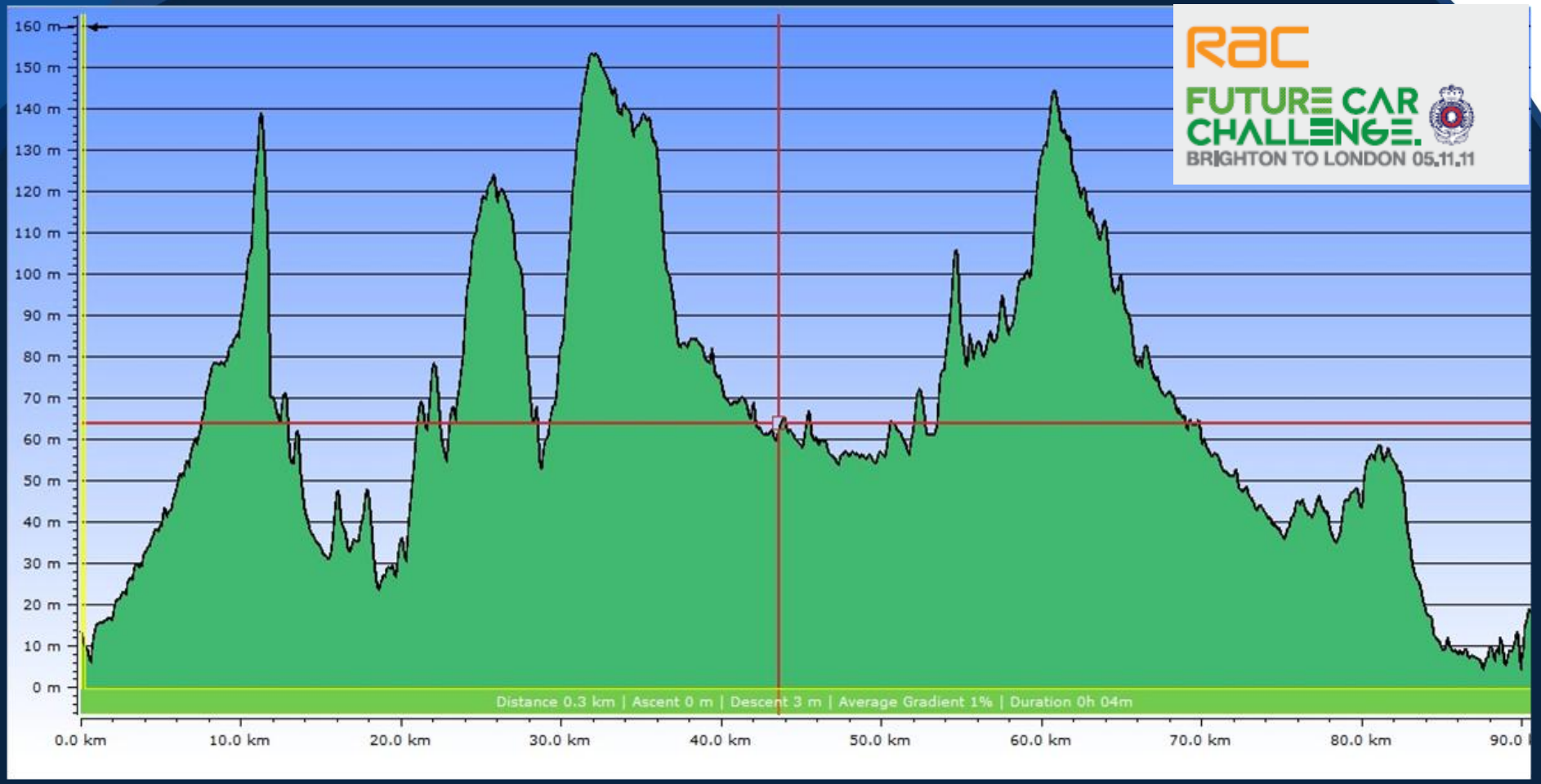
Imperial College London

Measurements

- **Energy consumption**
  - Fuel energy: (Distance/MPG)*(Energy Density)
  - Electrical energy: **GEMS** Data Loggers
    - Voltage & Current
    - Accounting for charging (93) & battery efficiencies (99%)
- **Driving behaviour**
  - GPS receiver to log speed, position & time

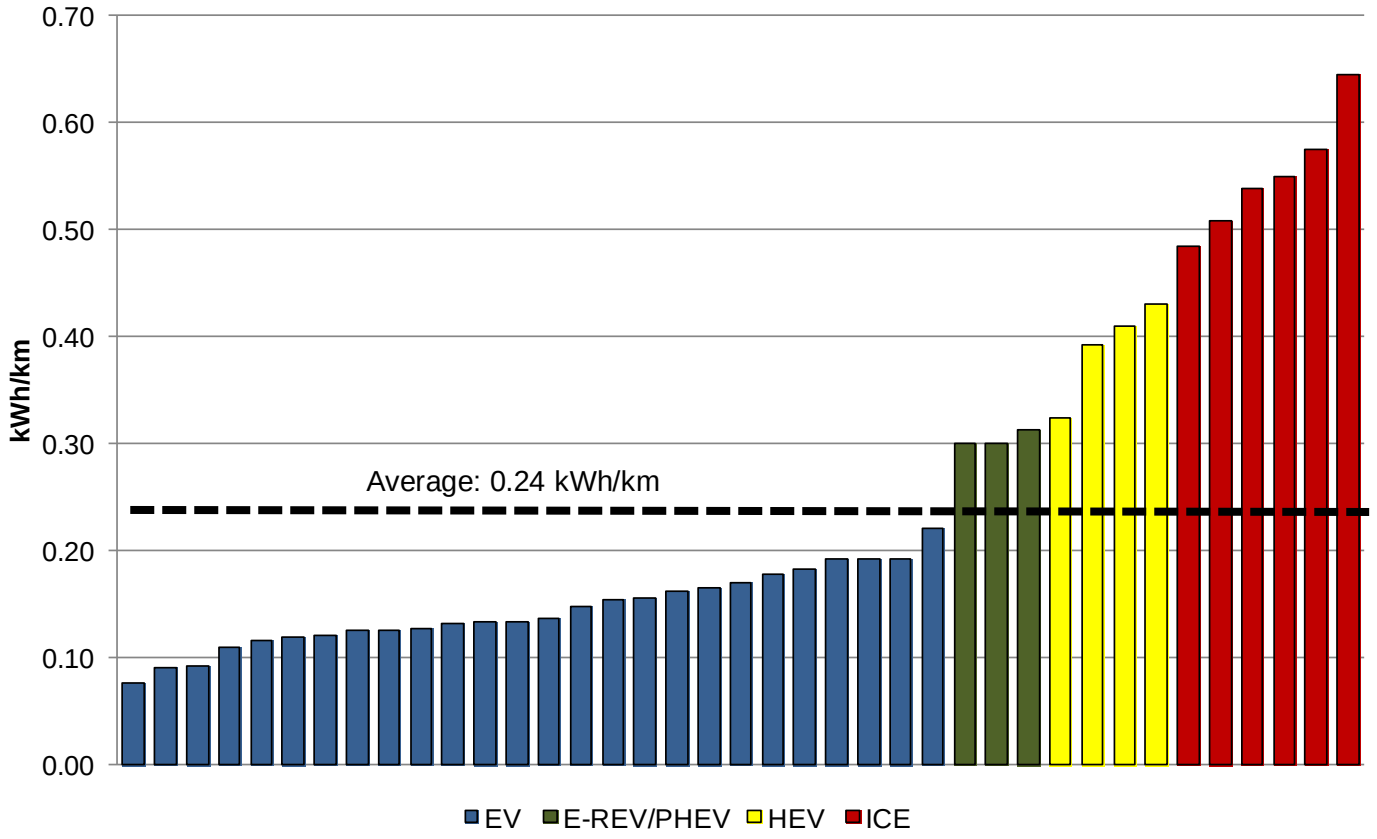
Imperial College London

The Route: Altitude Brighton to London

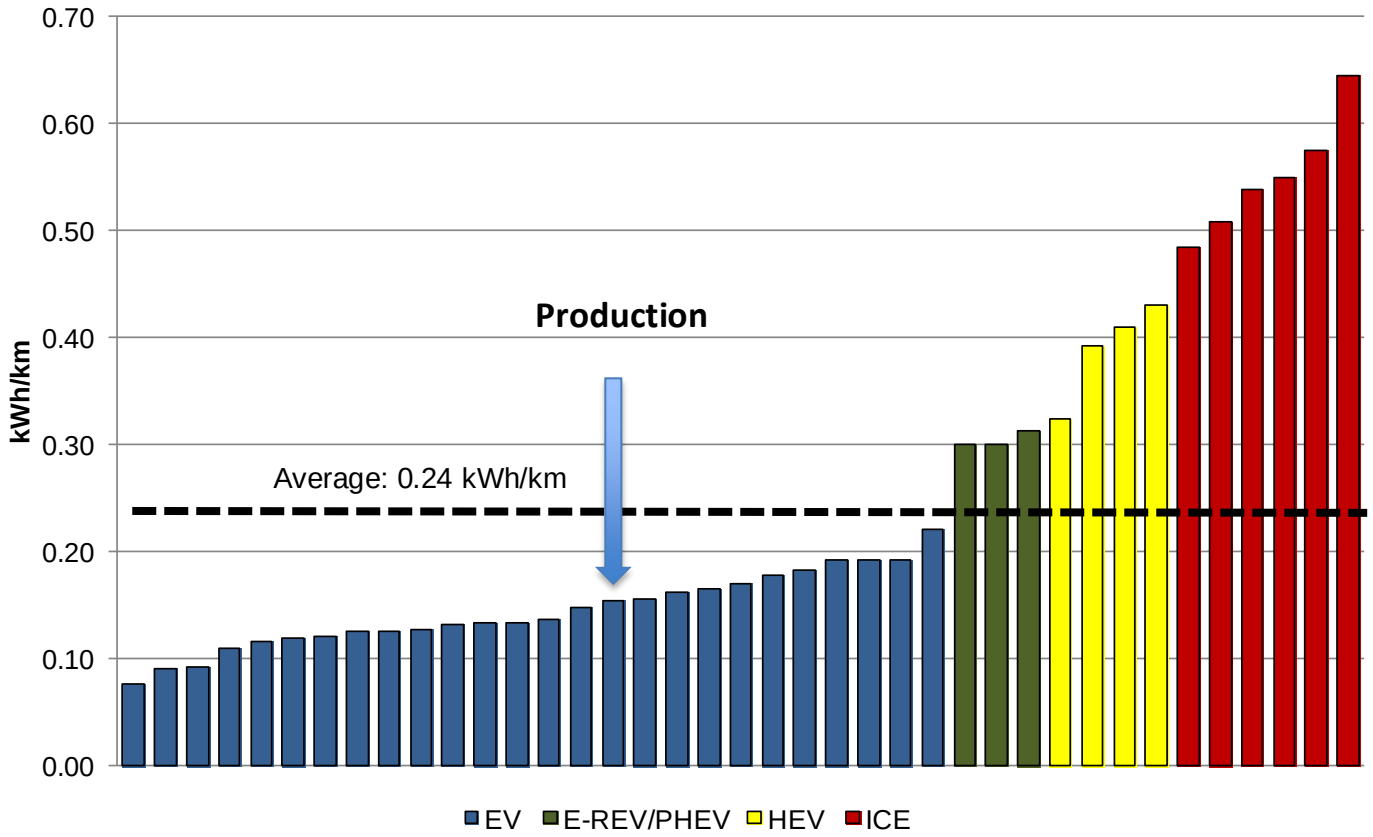


Energy Consumption

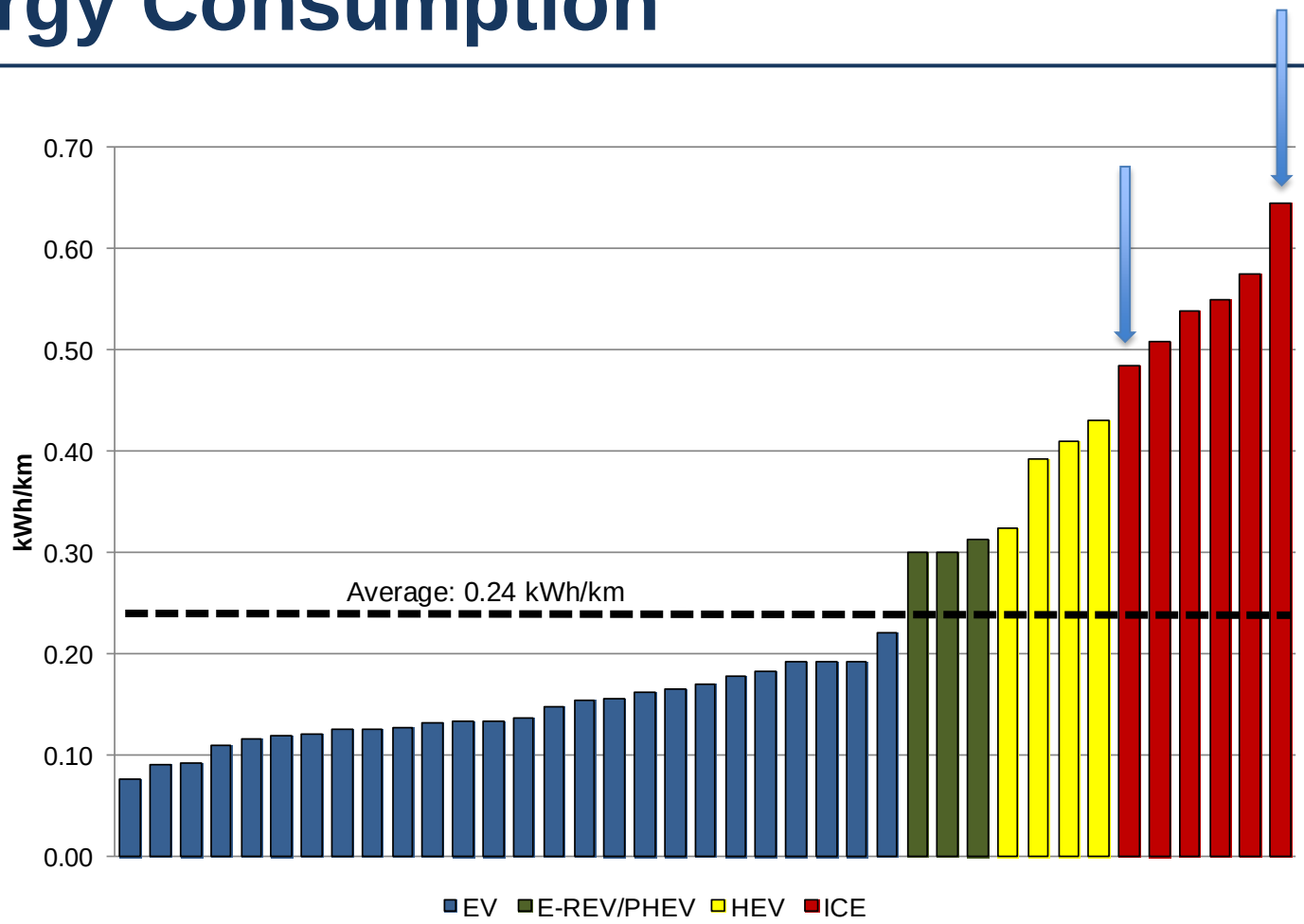
The larger the degree of power train electrification, the lower the energy consumption



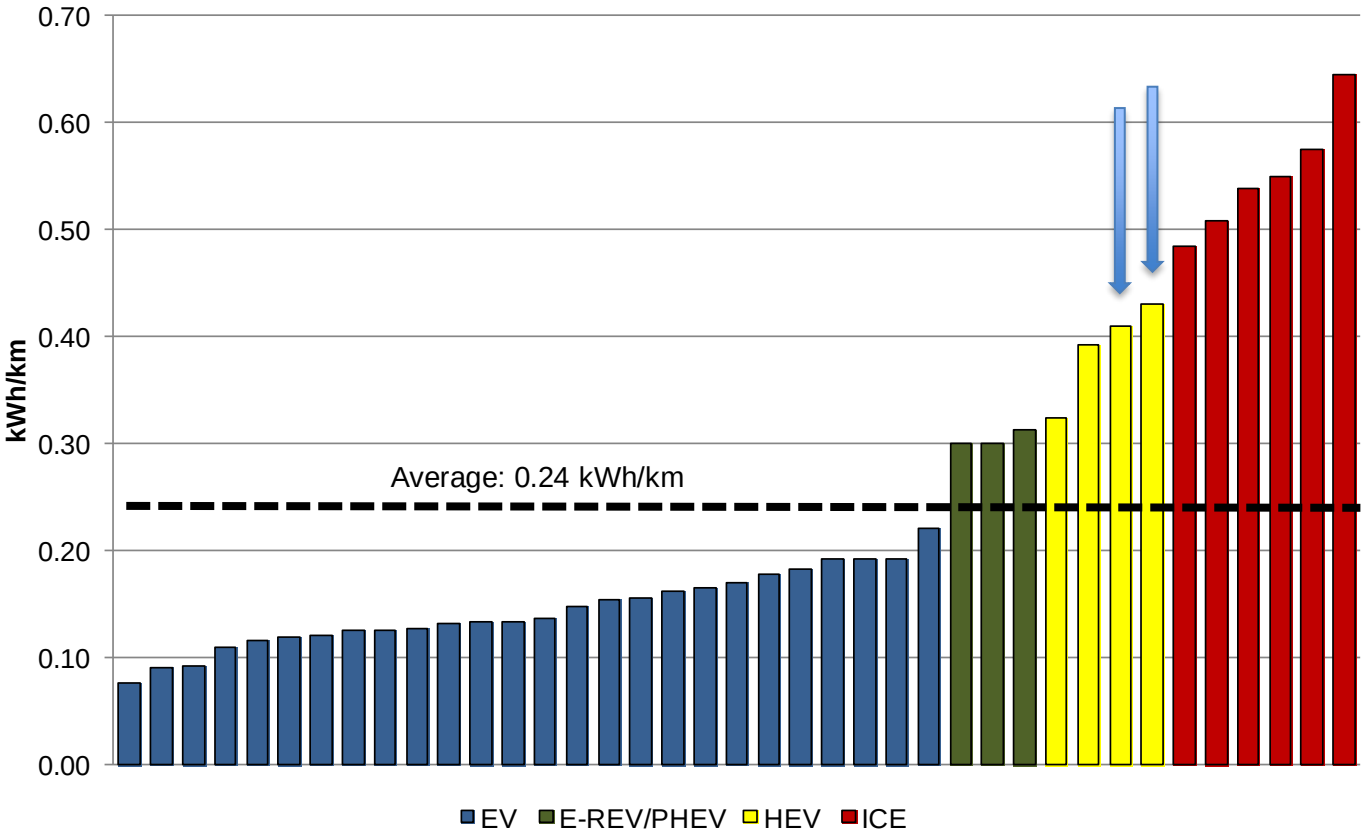
Energy Consumption



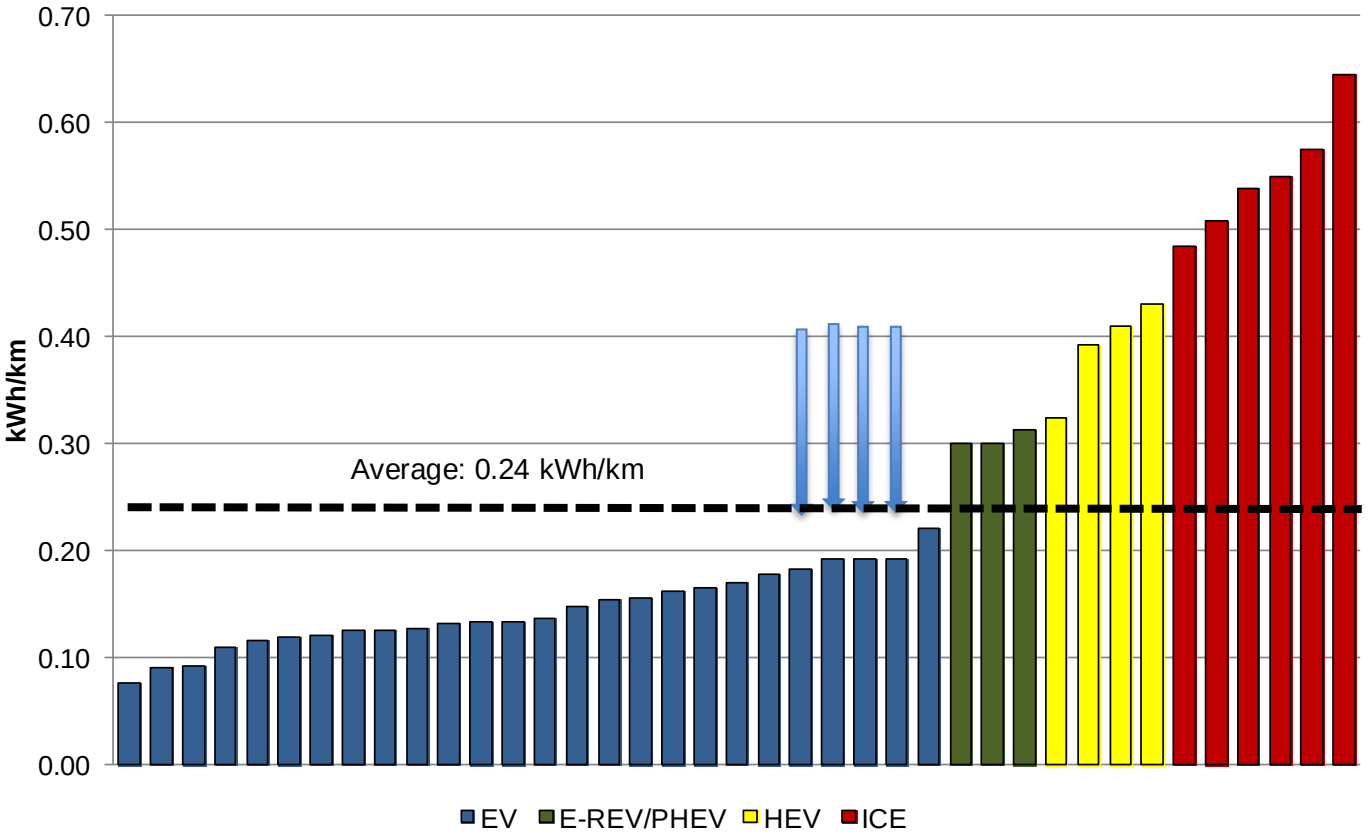
Energy Consumption



Energy Consumption



Energy Consumption



Imperial College London

Conversion to CO_2

USED IN THIS ANALYSIS:

Average Emissions Factor (AEF): **594** gCO_2/kWh

OTHER OPTIONS:

Marginal Emissions Factor (MEF): 690 gCO_2/kWh

This value is higher than the AEF due to the need to meet peak demand through the use of carbon-intensive sources (i.e. coal, gas).

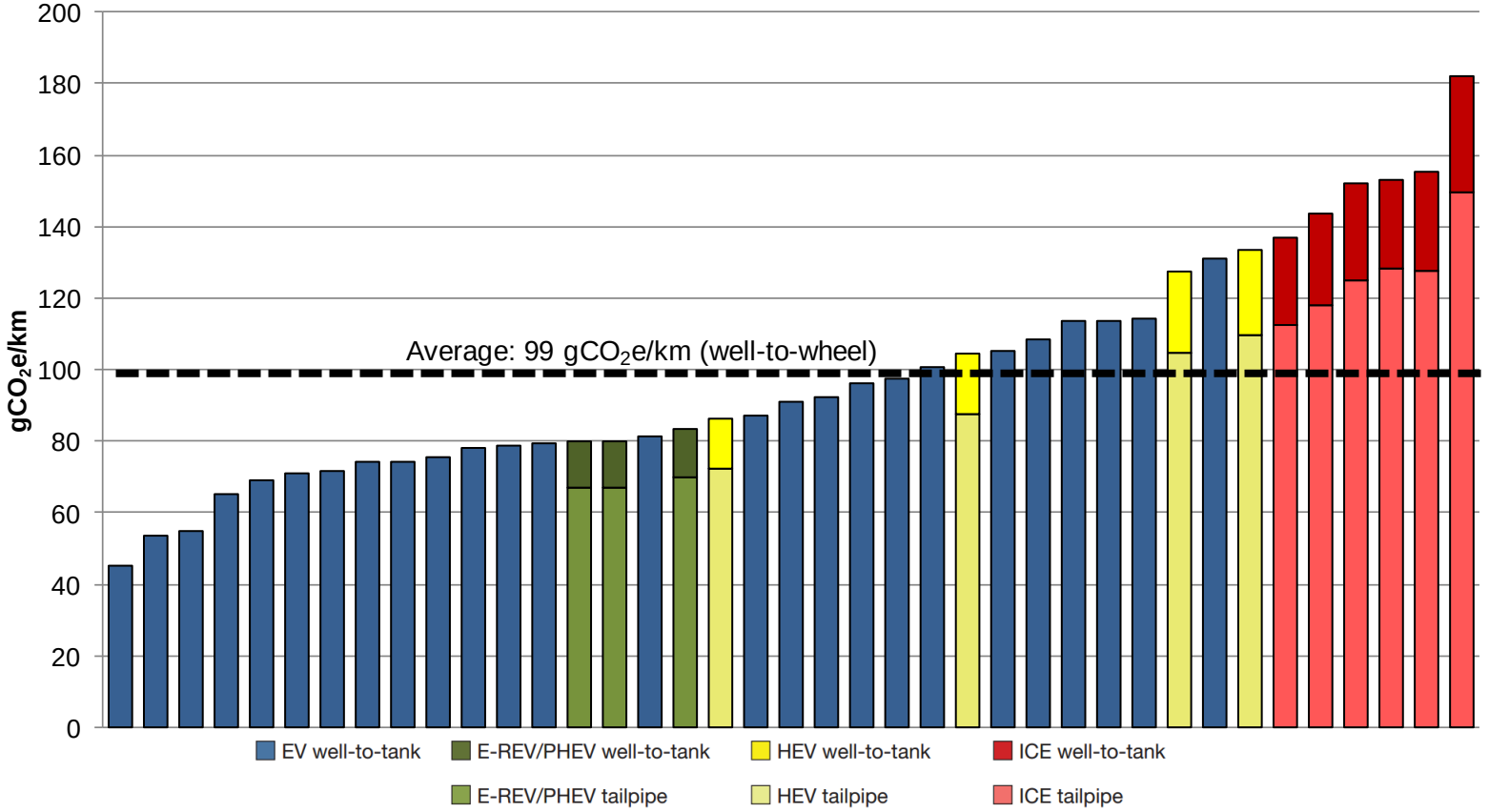
EV charging at night AEF 470 gCO_2/kWh

"Best case scenario"

Well-to-wheel and tailpipe comparison

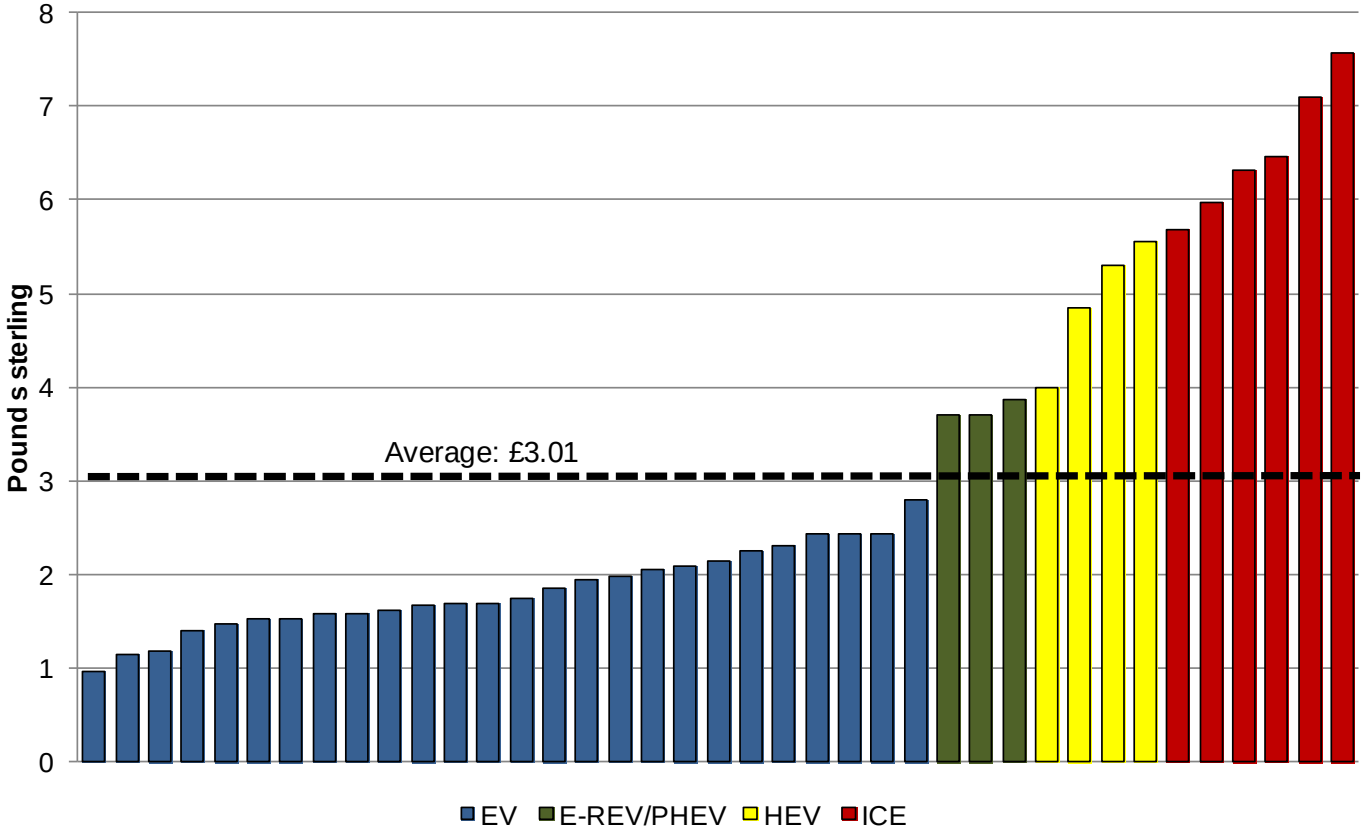
CO_2 Emissions

Slightly more mixed picture in terms of CO_2 emissions



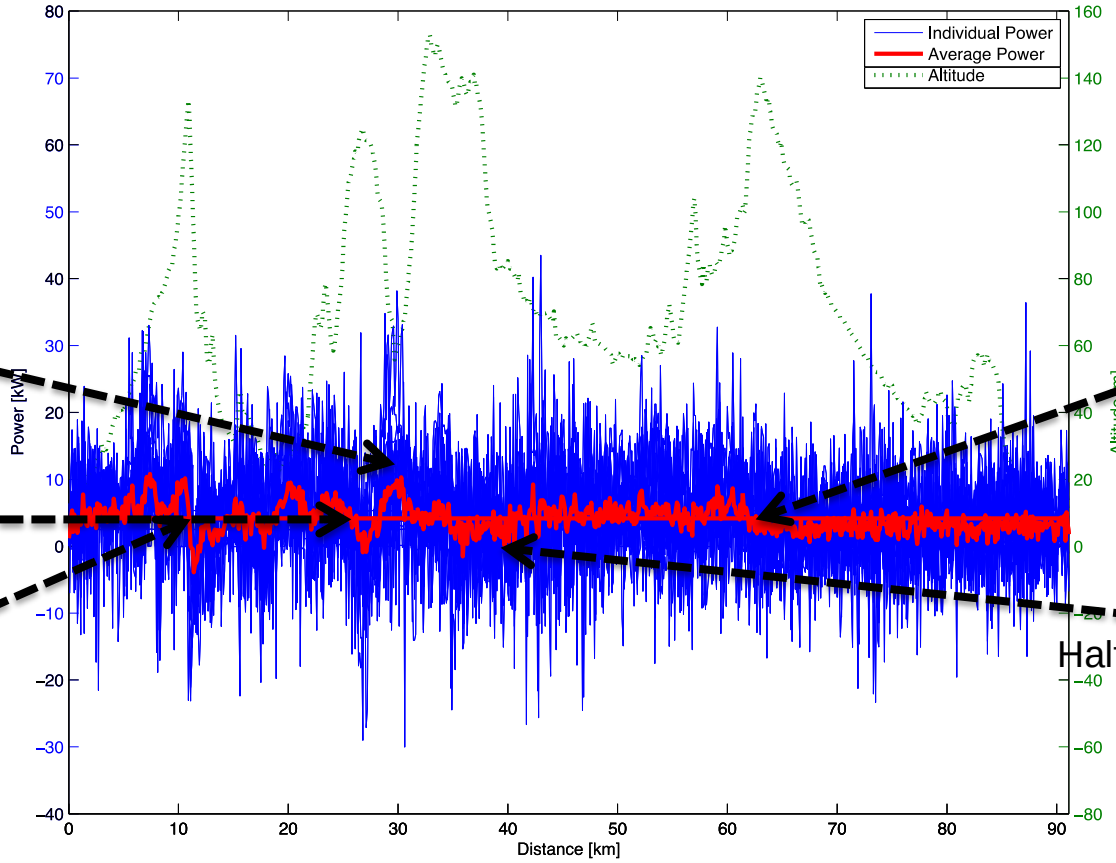
Fuel Costs

Fuel costs varied by a factor of up to 7



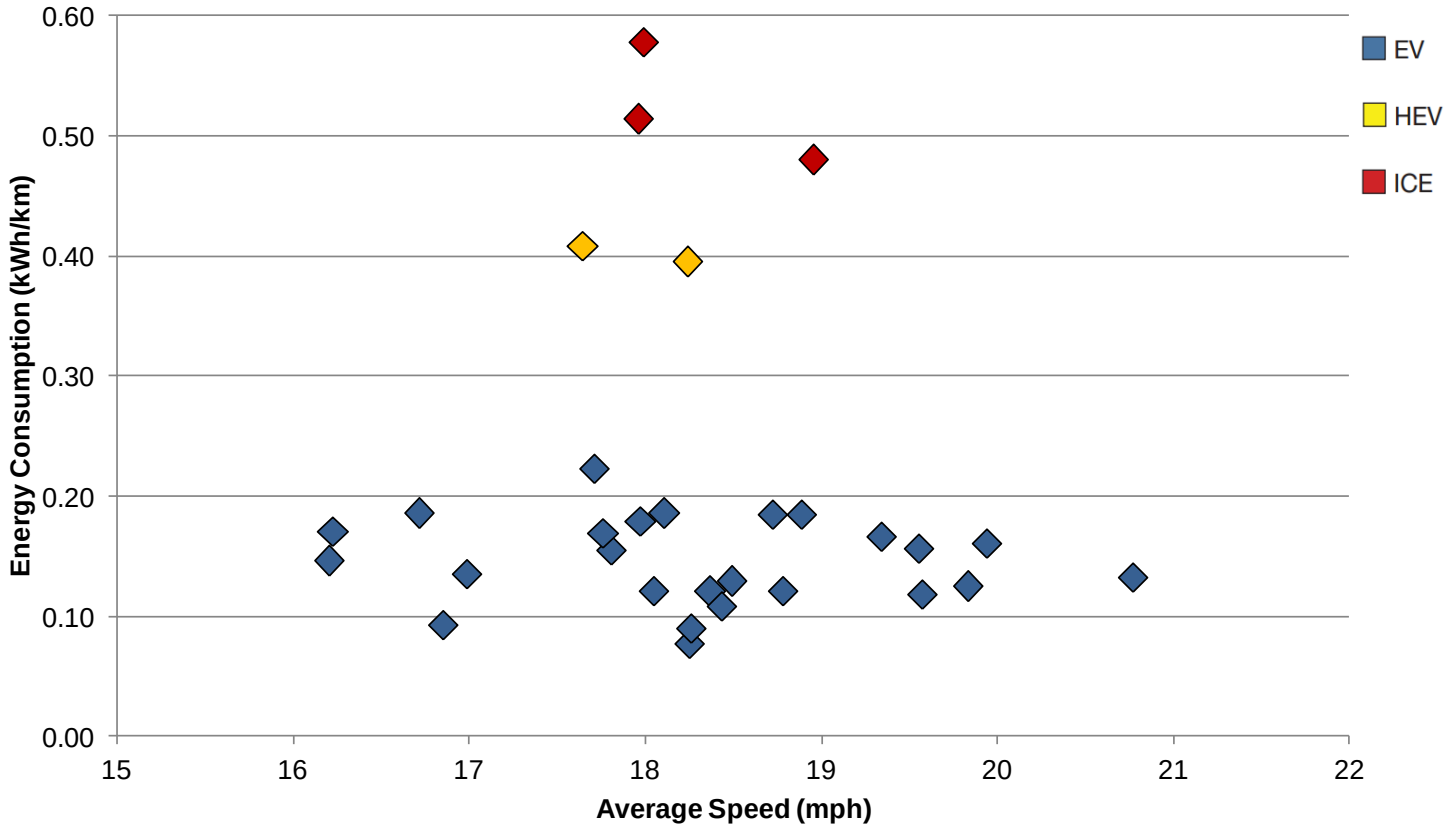
Driving Style – Power Consumption

Obvious differences along the way

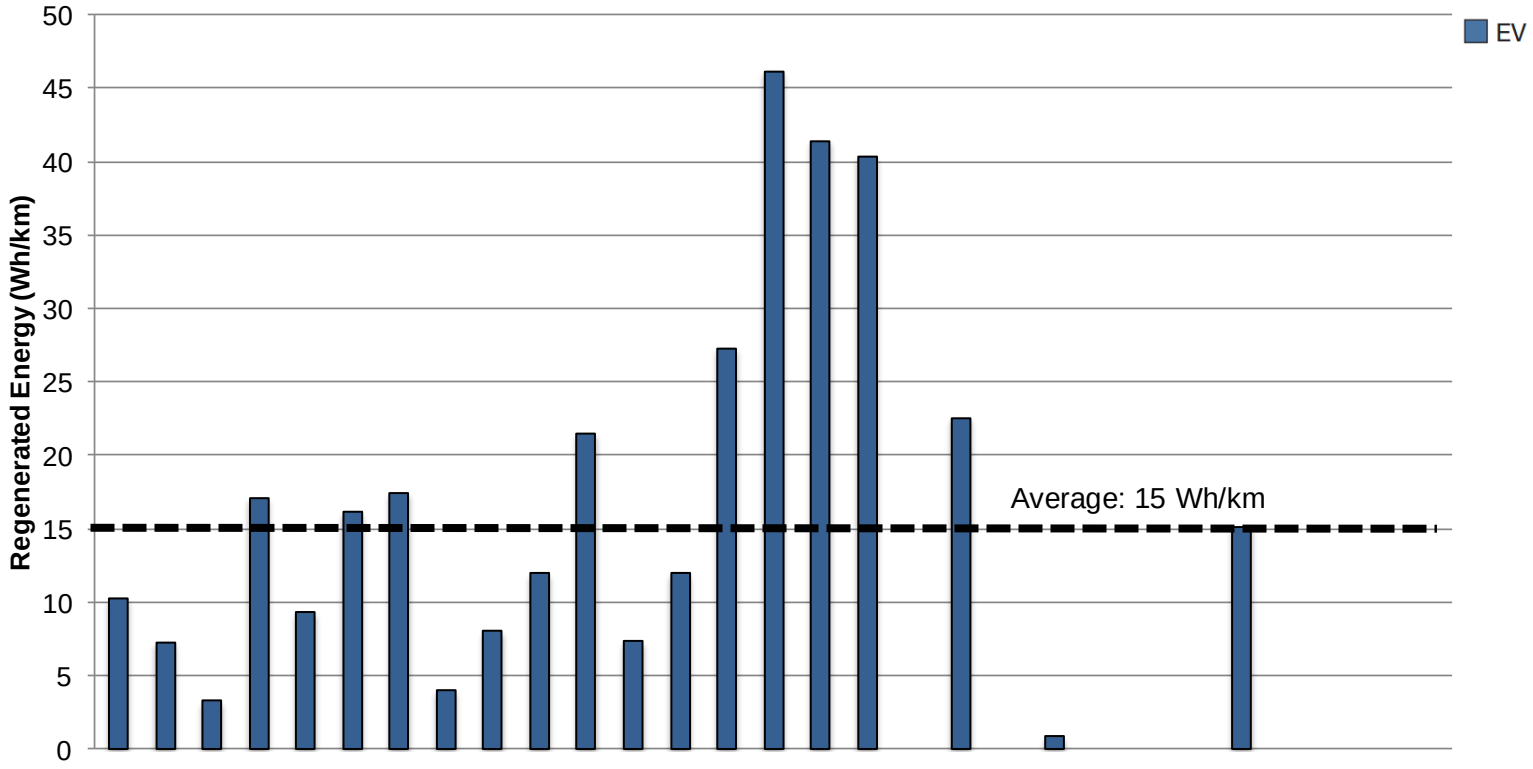


Driving Style – Average Speed

Average speed did not have an impact on energy consumption

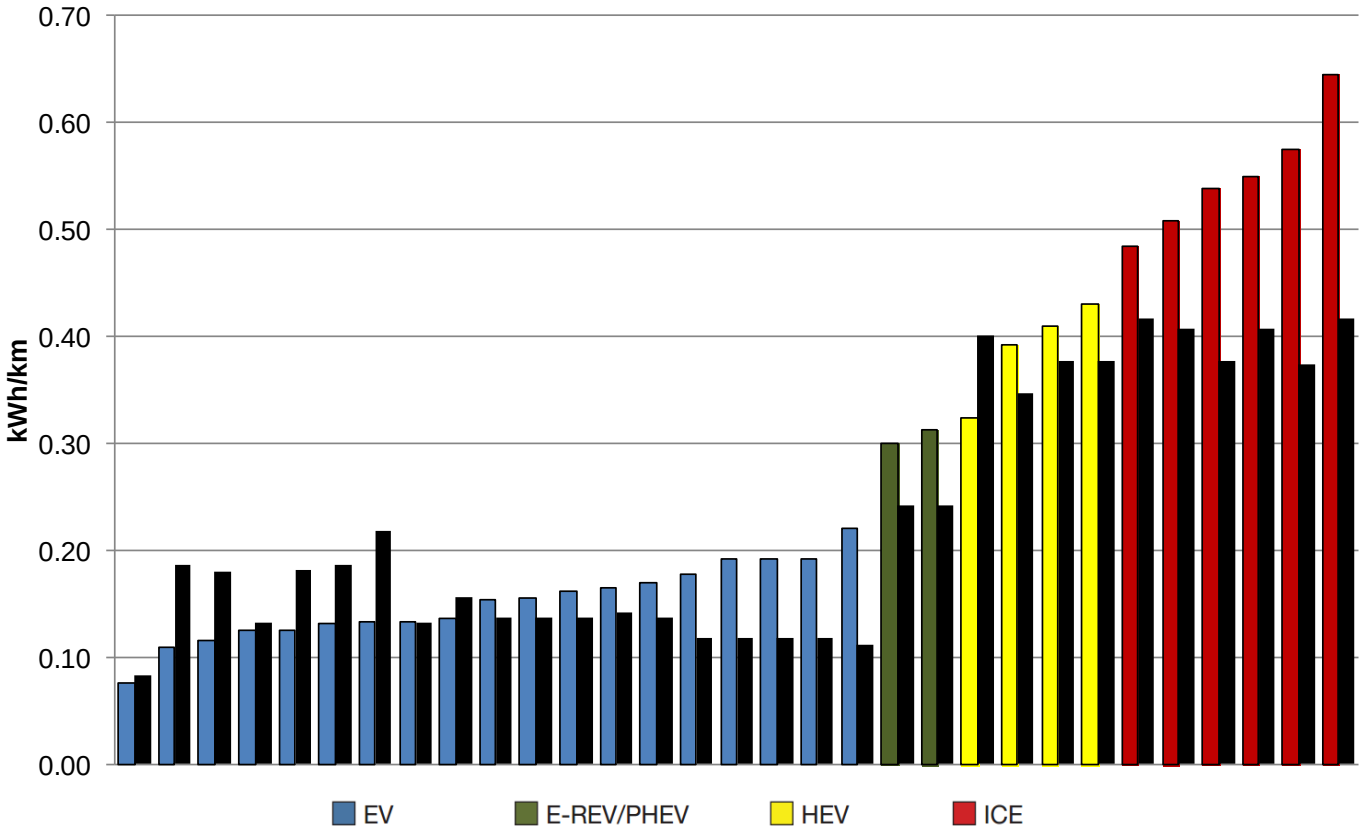


Regenerated Energy



Real-world vs NEDC Energy Consumption

Official and claimed NEDC energy consumption varied markedly from figures measured in the FCC



Imperial College London

Conclusions

- The larger the degree of power train electrification, the more efficient the vehicle
- Well-to-wheel CO_2 emissions were lowest for EVs and E-REVs/PHEVs, followed by HEVs and then ICE vehicles
- Discrepancy between official NEDC fuel economy, range and CO_2 emission figures on the one hand and real-world performance on the other
- EVs were the cheapest to run
- Average speed did not have an impact on energy consumption
- The less time spent on the accelerator, the less energy is consumed