European
Automobile
Manufacturers
Association

Mobile Air Conditioning efficiency

ACEA test methodology

Automotive Summit

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The Automobile Industry in Europe

Key figures

- ⇨ 16 major international companies/ groups
- ⇨ 12.6 million direct and indirect jobs
- ⇨ €26 billion in R&D spending, largest private investor
- ⇨ €28.6 billion of net trade contribution
- ⇨ €427.4 billion of tax revenues (EU15)

BMW Group	DAF	DAIMLER	FIAT GROUP
Ford	GM	JAGUAR | LAND ROVER	MAN
PORSCHE	PSA PEUGEOT CITROËN	RENAULT	SCANIA
TOYOTA	VOLKSWAGEN	VOLVO	VOLVO

Background

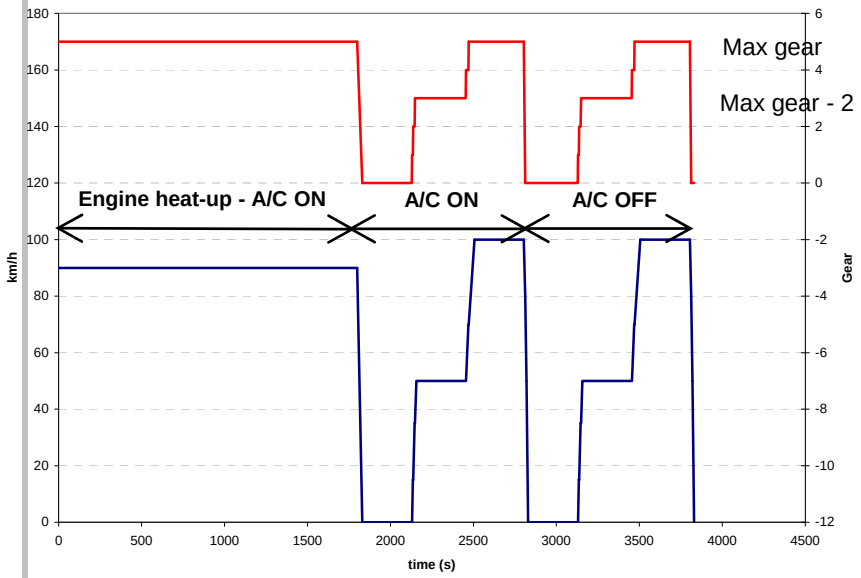
- **Following review of European Community strategy of 2007 to reduce CO2 emissions from cars + CV the EC should propose legislation on further reduction of 10 g CO2/km amongst others by setting min. efficiency requirements for mobile air-conditioning systems (MAC)**
- **Development of regulations on MAC systems on overall vehicle fuel consumption also in the US in preparation**
- **ACEA members have a lot of experiences since late 1990s on MAC fuel consumption for engineering purposes**
- **Standard OEM testing procedures are not applicable for type approval purpose**
- **ACEA has developed a simplified approach:**
  - ⇨ to adapt OEMs knowledge
  - ⇨ to consider technical and economical constraints of type approval activities

Content

- ACEA test methodology
- Analysis of test results
- ACEA Conclusions
- EC / TNO proposal MAC test procedure
- Summary / Next steps

ACEA test methodology - overview

• Test cycle summary:

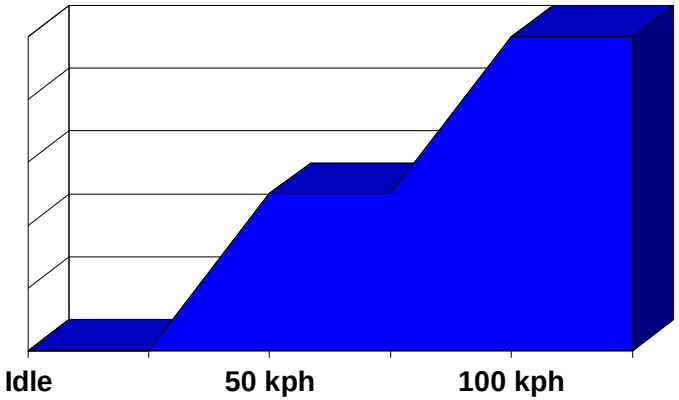


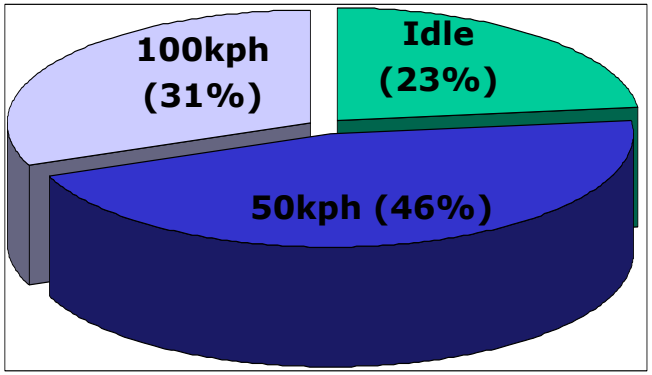
- **Steady state cycle:**
  - ➢ **pre-conditioning phase 30 min**
  - ➢ **2 equal driving phases (idle/50/100kph) with A/C on and off**
- **Measuring during steady state phases**
- **Performing of cycle once**

Ambient Temperature (T)	**25°C ± 2°C**
Relative Humidity (RH)	**40% RH ± 5%**
Solar load	**• No lamps in test chamber • by adapting air mass flow into cabin**
Air mass flow (cabin)	**>210 kg/h (solar load 700W/m²)** **Report on vehicle mass flow to be included for verification**
Cooling capacity	**Vents temperature < 15°C**
HVAC settings	**• Full vents, no forced recirc mode • Mixing flap moving free**
Glazing effect	**• Not suitable tbc in test • If needed; by external coefficient**
Test duration	**1 hour (30' + 15' + 15')**

ACEA test methodology (1/2)

- **Calculation of cycle average fuel consumption from test results**





Each driving phase →
5 minutes duration

With different weight in final result (cycle average)

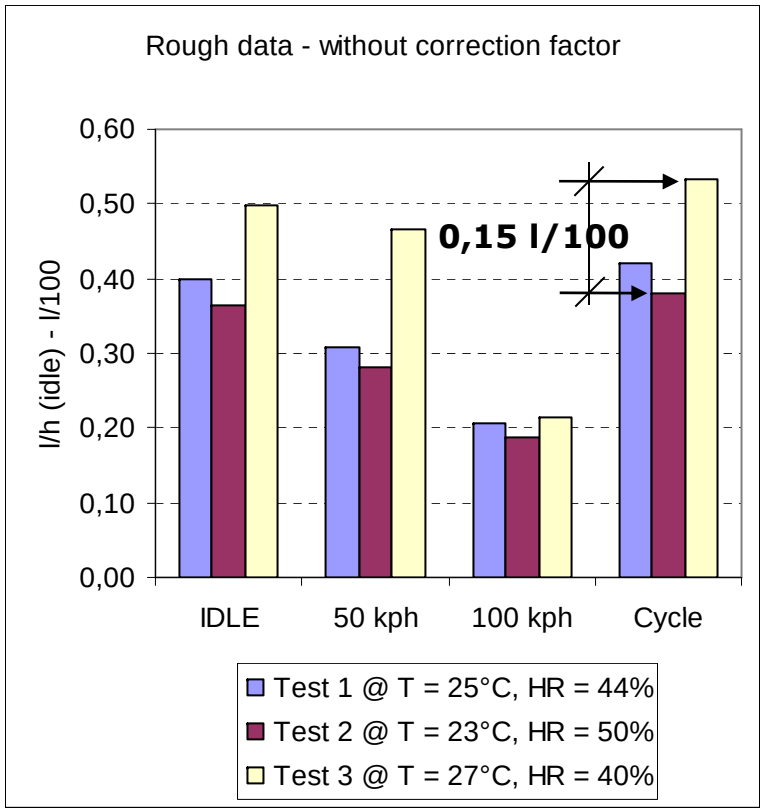
Representative of real customer usage

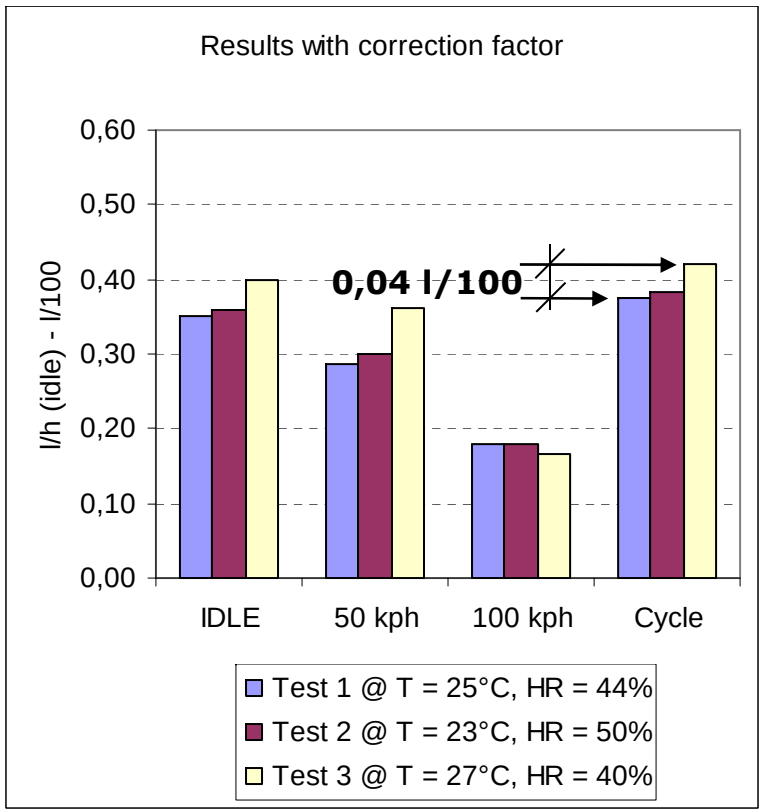
- **Results are shown in:**
  - AC absolute fuel figures over consumption (l/100km)
  - % of AC OFF vehicle consumption:

$$\frac{\text{Vehicle consumption with AC ON - Vehicle consumption with AC OFF}}{\text{Vehicle consumption with AC OFF}}$$

ACEA test methodology (2/2)

- **Correction factors for ambient T & RH**
- **Simple methodology to calculate a correction factor**
  - K_corr = **Δh_std** / **Δh_real**





- **Deviation of results < 0.04l/100km, due to correction factor**

Vehicles tested (PSA & Renault)
Technical definition

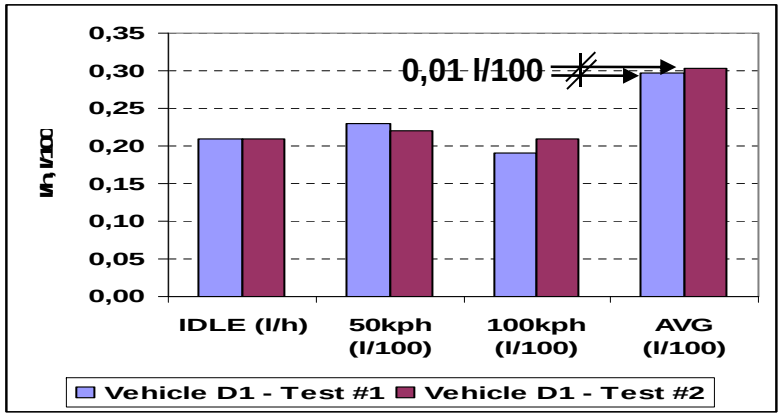
- **Carbon Content test bench (Chassis dyno test bench)**
- **With blower mass flow at 230kg/h**

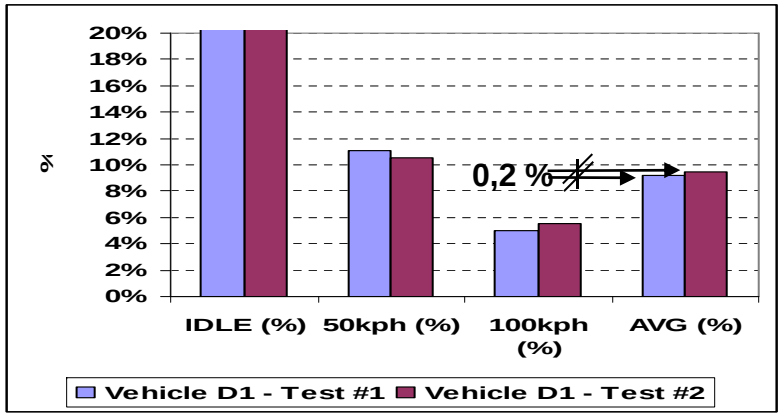
Vehicle	Vehicle type	Engine	A/C technology
Vehicle D1	***B-Segment***	1.6L Diesel	**Automatic, External control compressor (120cc) with clutch, TXV**
Vehicle D2	***D-Segment luxury***	2.0L Diesel	**Automatic, External control compressor (140cc) clutchless, TXV**
Vehicle D3	***B-Segment***	1.5L Diesel	**Manual, Internal control compressor (160cc) with clutch, TXV**
Vehicle D4	***B-Segment***	1.5L Diesel	**Manual, Fixed displacement compressor (Rotary 117cc), TXV**
Vehicle G1	***B-Segment***	1.4L Gasoline	**Manual, External control compressor (120cc) with clutch, TXV**
Vehicle G2	***C-Segment***	2.0L Gasoline	**Automatic, External control compressor (140cc) clutchless, TXV**
Vehicle G3	***B-Segment***	1.4L Gasoline	**Manual, Internal control compressor (120cc) with clutch, TXV**
Vehicle G4	***B-Segment***	1.3L Gasoline	**Manual, Fixed displacement compressor (Scroll 60cc), TXV**

New results

Assessment of accuracy, repeatability, influence of test benches & operators

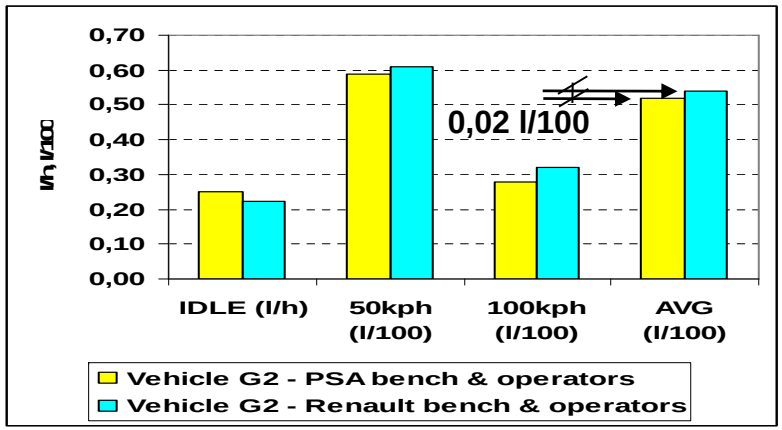
- **Test repeatability with same car, bench & operator:**

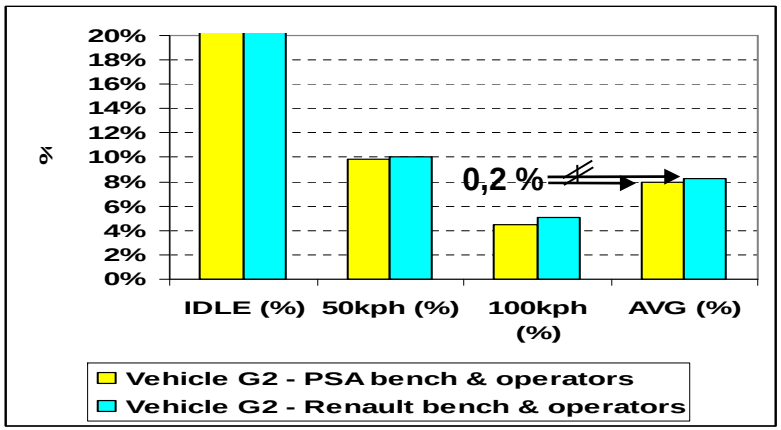




➢ **Max. deviation of 0.01 l/100 + 0.2% of overall fuel consumption**

- **Test repeatability with same car, different benches & operators :**

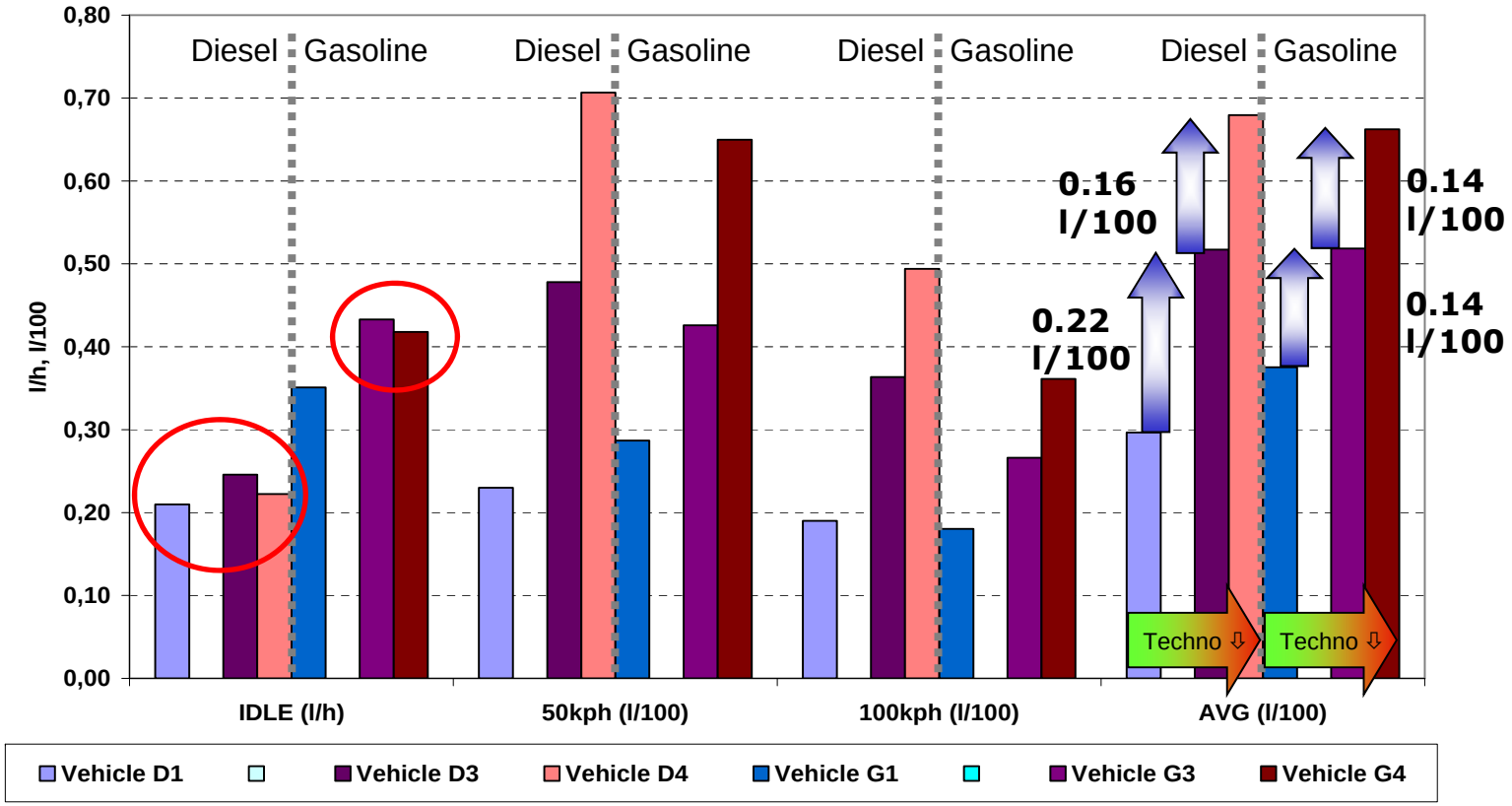




➢ **Maximum deviation is kept in the same range**

Vehicles tested (PSA & Renault)
Global picture (in l/100km)

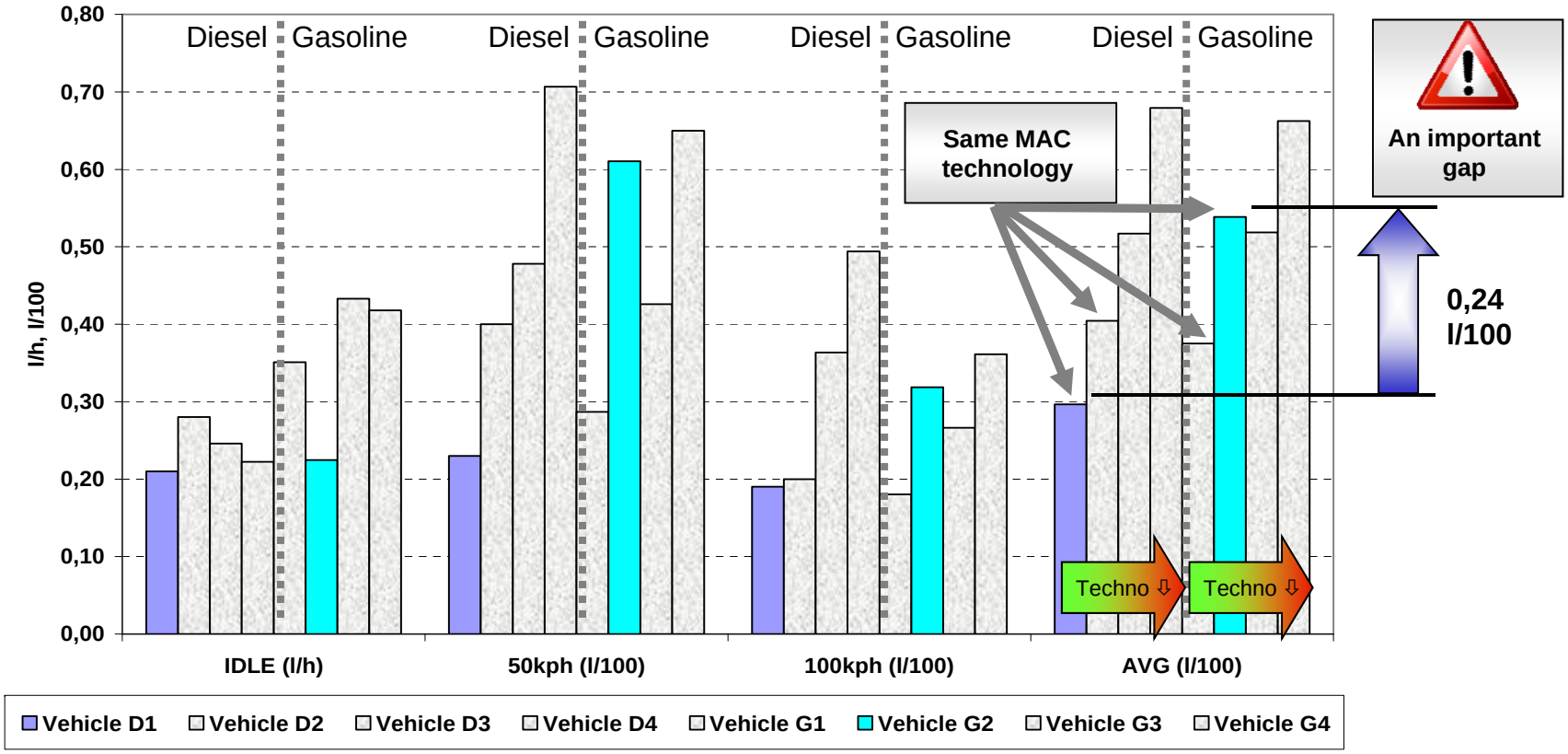
Influence of MAC technologies (equivalent engine)



- **Significant differences in fuel consumption for different MAC technologies (with equivalent engine types)**
  → **Measured range between 0.30 to 0.68 l/100 of overall fuel consumption**

Vehicles tested (PSA & Renault)
Global picture (in l/100km)

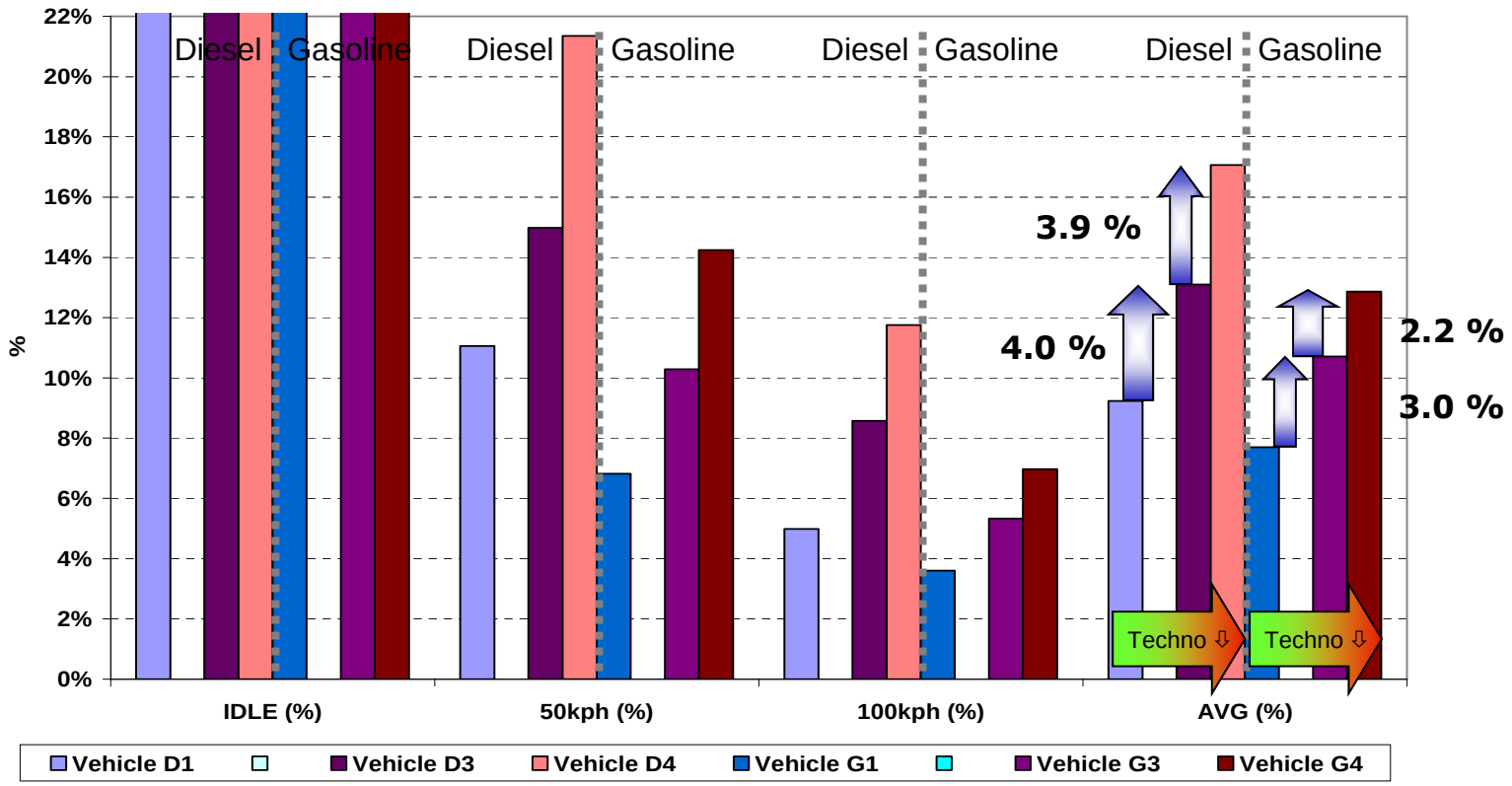
Influence of engine type, with same MAC technology



- **Communicating the result in l/100km → first order or magnitude is directly related to engine efficiency**

Vehicles tested (PSA & Renault)
Global picture (in %)

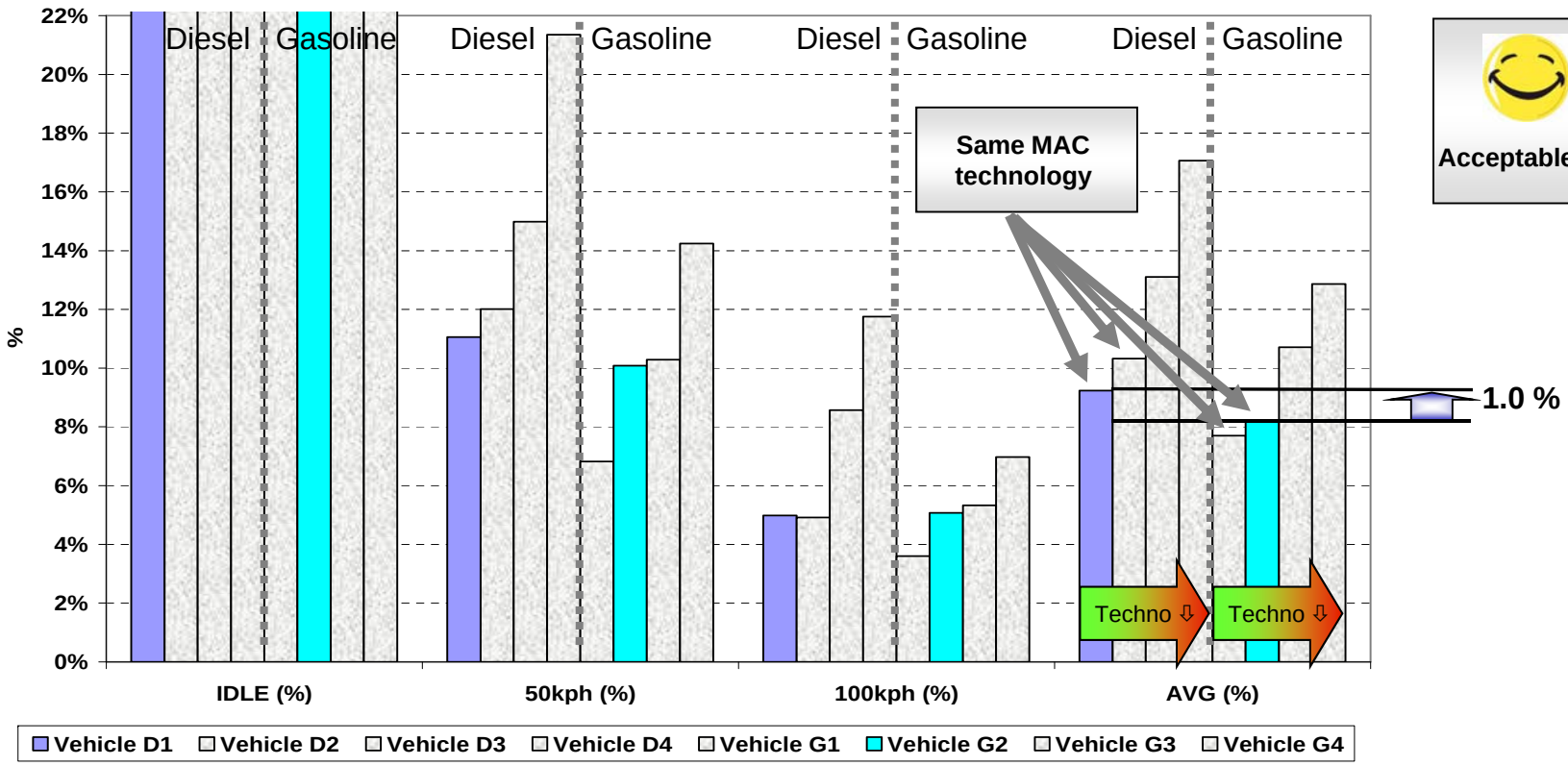
Influence of MAC technologies (equivalent engine)



- **Significant differences in fuel consumption for different MAC technologies (with equivalent engine types)**
  - → **Measured range between 7.7% to 17% of overall consumption**

Vehicles tested (PSA & Renault)
Global picture (in %)

Influence of engine type, with same MAC technology



- **Final value in % reflects better the influence of AC technology & AC good engineering**

ACEA conclusions (1/2)

- **Measurement consistency is very good between both test benches:**
  - ⇨ Very similar results (less than 0.11 l/100km + 1.6% accuracy), even knowing that:
    - Test benches are different
    - Measurements facilities are different
    - Car drivers are different
- **According to those who made the measurements, test procedure is simple, and then acceptable**
- **Correction method:**
  - ⇨ Compensates deviation of measurements due to fluctuation of Temperature and Relative Humidity
  - ⇨ Easily applicable by type approval authorities
- **Differences between MAC technologies can be measured**

⇨ ACEA Type Approval test methodology has been proven reliable

ACEA conclusions (2/2)

- **If result is given in l/100km (absolute over consumption):**
  - ⇨ First order in over consumption is directly related to engine efficiency
  - ⇨ **AC technology itself is in a second order of magnitude**

  Real customer consumption will be assessed (l/100km or CO2/km), **AC labelling may be misunderstood** in this case
- **If the result is given in %:**
  - ⇨ Very similar AC technologies seem to give very similar results, can disadvantage Diesel vehicles (A/C off fuel consumption low)
  - ⇨ *Result more related to AC technology + AC good engineering*, especially if Diesel and Gasoline are considered separately
  - ⇨ *Best approach if purpose is MAC efficiency evaluation* – but **AC labelling scale for Diesel and Gasoline cars should be different**

More test results are necessary, to be able to:

⇨ *Take position in this topic*

⇨ *Establish a fair classification table for labelling*

EC/TNO proposal MAC test procedure

- **Stakeholder meeting October 7th:**
  ACEA comments to the draft test protocol issued 09/2010

Topic	EC / TNO proposal	ACEA proposal	Decision
MAC on with T <18°C	Verification during soaking phase → bonus between 20% and 50%.	Subject out of the scope Safety concern to be clarified (defog)	Topic included in TNO report Input needed for decision
Testing time -SOC battery	2 tests (max SOC & min SOC)	Only 1 test with max. SOC	Only 1 test with max. SOC
Testing time -Soaking -Repetition	8h soaking at 25°C ± 2°C and 50%RH ± 5% (in type approval facility)	8h storage at 20°C<T<30°C without considering RH (in storage room)	OK for ACEA proposal
Air mass flow	Fixed value of 230kg/h	3 different levels depending on vehicle cabin size	None at this stage
Correction for vehicle glazing	Fixed categories for every vehicle type	Apply method for every vehicle type	None at this stage. More data required.
Temperature sensors	Measuring temperature at drivers head level	Measuring temperature at the front vents	Measuring temperature at the front vents, with one cabin sensor for confirmation during pilot phase

Summary / Next steps

- ACEA agrees on the fundamentals of TNO and consultants draft test protocol
- Some open points still need to be discussed and decided
- ACEA is ready to provide detailed information on request to support the finalization of the procedure
- EC proposed physical test procedure which should run as a pilot from November 2010 to April 2011
- ACEA is willing to contribute in the pilot phase tests with a representative range of vehicles
- Decision on how to make labeling/classification of MAC system should be done after pilot phase
- ACEA is proposing MAC labeling without figures (based on relative consumption (%))

Thank you!

European Automobile Manufacturers Association
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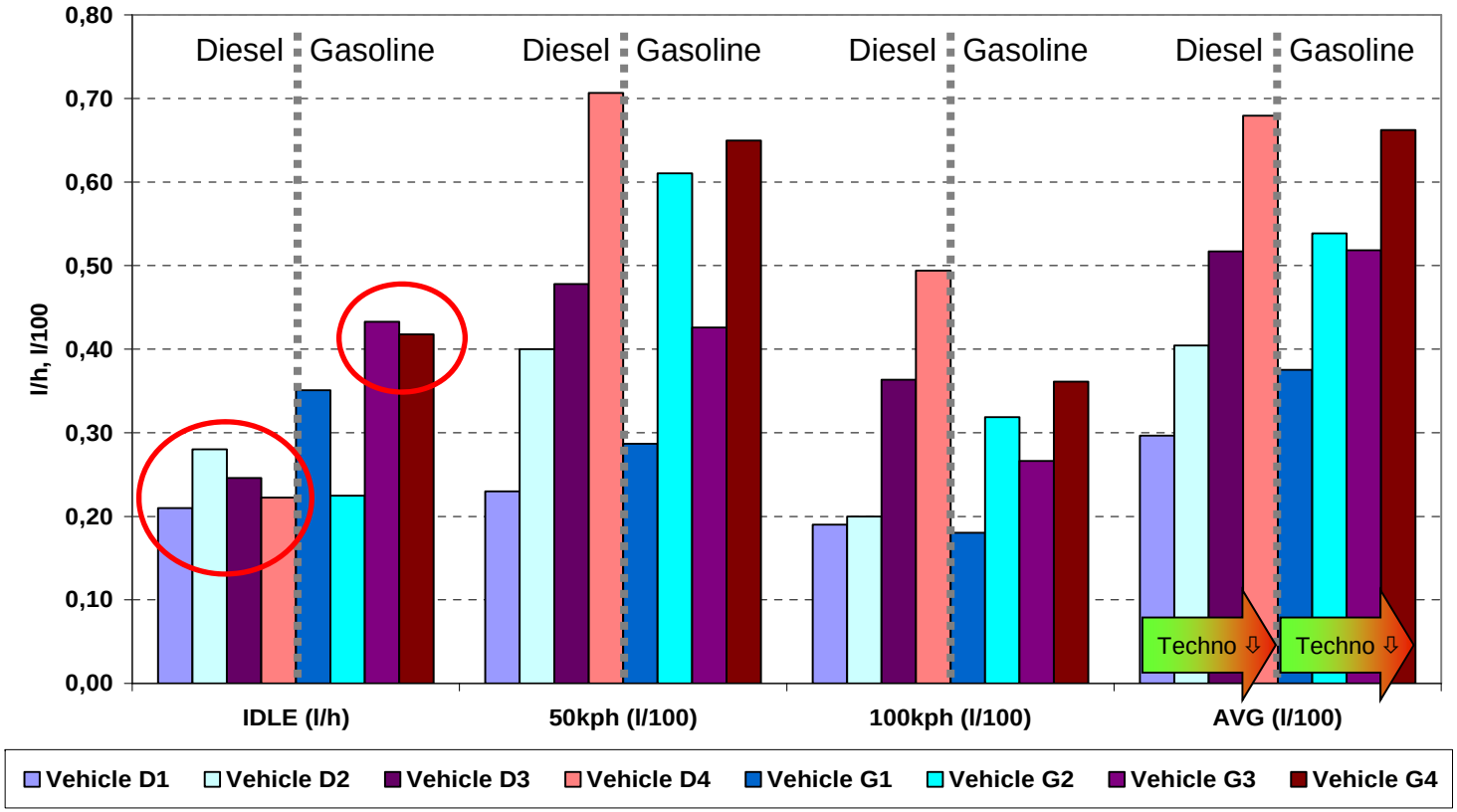
Backup

Vehicles tested (PSA & Renault)
Global picture (in l/100km)

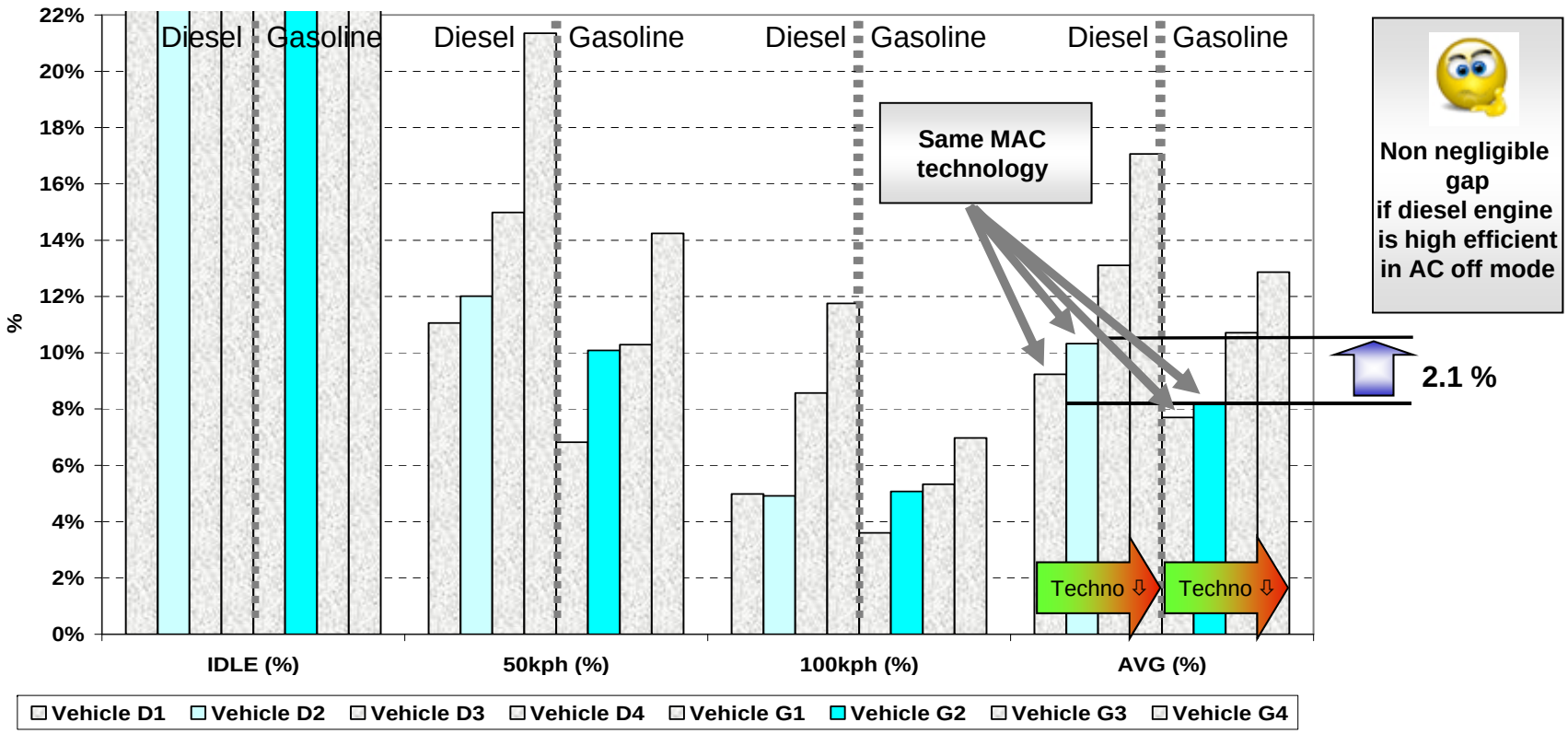
Influence of MAC technologies (equivalent engine)



- **Idle condition alone cannot discriminate these A/C technologies**

Vehicles tested (PSA & Renault)
Global picture (in %)

Influence of engine type, with same MAC technology



- For Diesel vehicles where AC Off fuel consumption is low, result in % may be amplified; makes comparison diesel + gasoline cars equipped with similar AC technology difficult
  → Considering Diesel and Gasoline engines separately