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The impact of 20 mph limits on carbon emissions and air quality

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Who is Ricardo-AEA?

- **Ricardo-AEA**
  - A global sustainability consultancy
    - Air and environmental quality
    - Energy and climate change
    - Resource efficiency and waste management
    - **Sustainable transport**
    - Chemical emergency and risk management
    - Knowledge management
  - Responsible for the UK's National Atmospheric Emissions Inventory (NAEI) since 1973!
  - Leading advisor to the Committee on Climate Change for UK carbon budgets

The impact of 20 mph limits on carbon emissions and air quality

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- **An admission**
  - **I can't tell you the definitive answer!**
  - **...but then neither can anyone else!**
  - **So this presentation is a review of:**
    - **What people say**
    - **What the evidence is**
    - **What conclusions we can draw**

The impact of 20 mph limits on carbon emissions and air quality

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- There is no direct relationship between fuel economy and posted speed limits - carbon emissions / fuel economy and air quality are only impacted through achieving behaviour change
- There are strong arguments in favour of 20 mph limits based on safety benefits, as well as noise reduction, health benefits, and quality of life

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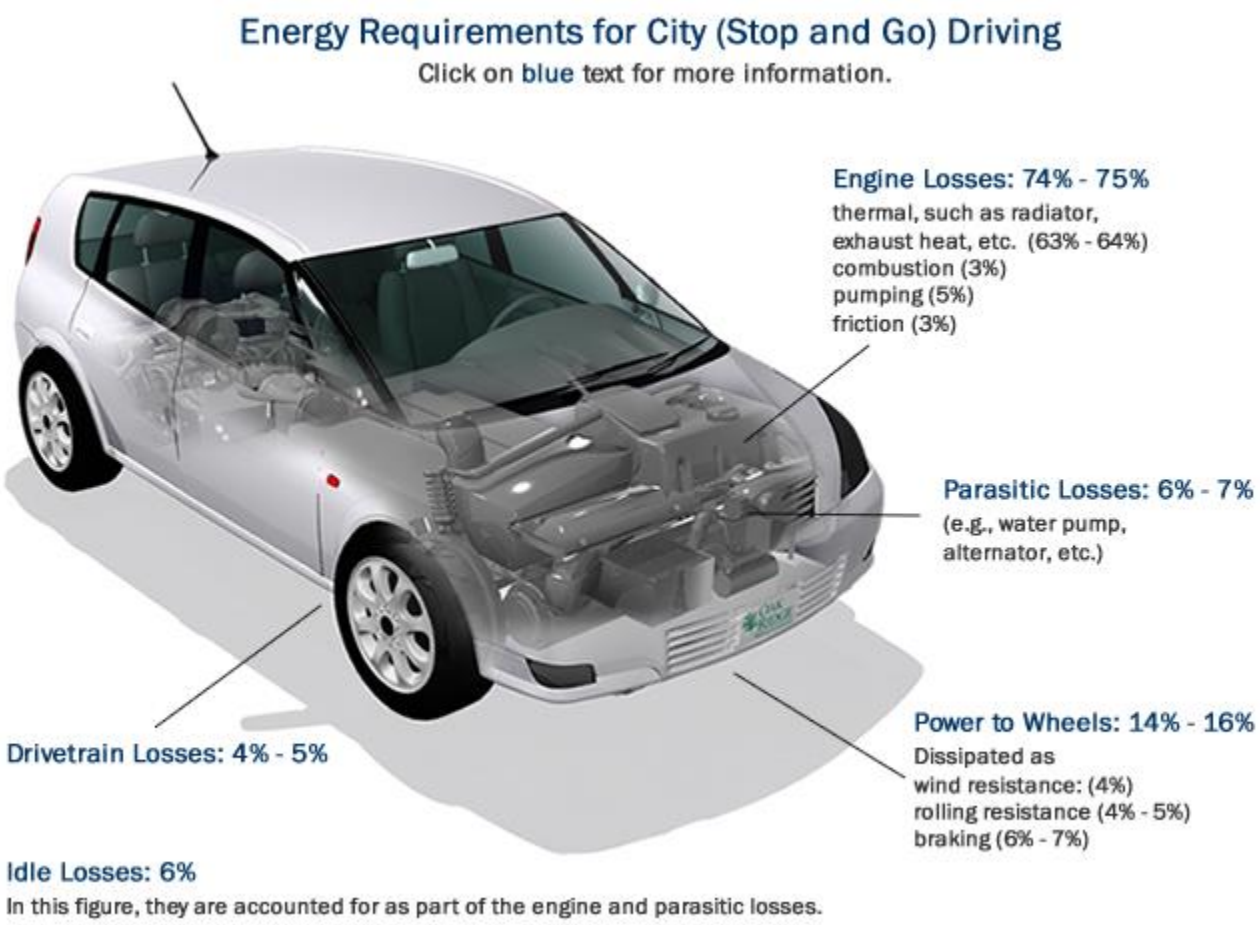
Energy use in stop-start driving

- About 85% of fuel energy is lost before it gets to the wheels
- Only about 0.5% of fuel actually moves the driver



Source: US DoE, http://www.fueleconomy.gov/feg/atv.shtml

What people say about 20 mph and carbon emissions

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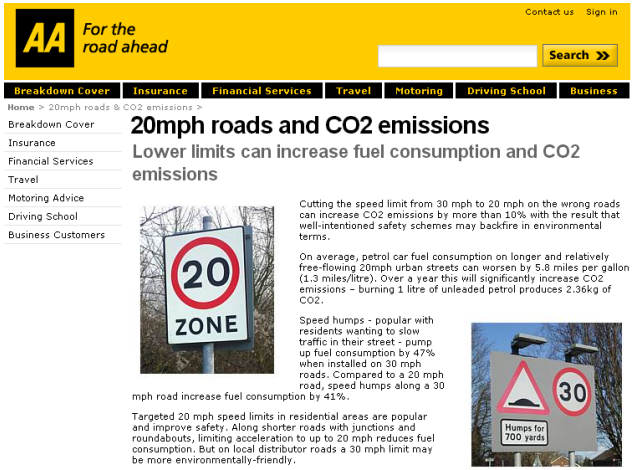
- ***AA*** *– "Cutting the speed limit from 30 mph to 20 mph on the wrong roads can increase CO_2 emissions by more than 10%"*
- **RAC -** *"According to the Highways Agency's figures, at 30mph average CO_2 emissions for vehicles (including 10% Heavy Goods Vehicles) stands at 188g/km, whereas at 20mph this rises to 221g/km."*
- **DfT's – Basic Local Authority Carbon Tool –** predicts increases in CO_2 emissions of around 20% as a result of *average* speeds being reduced from 30 mph to 20 mph
- **TRL – Carbon dioxide emissions:** *"Reducing speeds to 40mph is likely to have a positive impact on vehicle emissions; reducing speeds beyond ~40mph is likely to have a disbenefit."*

- **TRL - A summary of the evidence on the costs and benefits of speed limit reduction 2012**



What people say about 20 mph and carbon emissions

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- "*It is unlikely that imposing strict speed limits in urban areas has a significant influence on emissions of NOx or CO_2 .*" (Luc Int Panis Carolien Beckx and Steven Broekx IMPACT OF 30 KM/H ZONE INTRODUCTION ON VEHICLE EXHAUST EMISSIONS IN URBAN AREAS, 2011)
- "*In principle, driving more slowly (at a steady pace) will always save fuel and carbon dioxide emissions unless a quite unnecessarily low gear is being used.*"
  Department for Transport
- Percentage change in vehicle emissions and fuel use with speed change from 50 kph (31 mph) to 30 kph (19 mph):
  - 7% increase in fuel consumption (aggressive/2nd gear)
  - 7% decrease in fuel consumption (calm / 3rd gear) (Newman and Kenworthy 1992)
- "When 30 kph zones were introduced in Germany, car drivers on average had to change gear 12% less often, use their brakes 14% less often and require 12% less fuel." An illustrated guide to traffic calming, Dr Carmen Hass-Klau, 1990

Why is there this difference of opinion?

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- **There are four main sources of data being used:**

- 1. Steady-speed fuel consumption and emissions tests
- 2. “Emission factor” curves
- 3. Simulation modelling of vehicle emissions
- 4. Real-world observations and measurements

- Conclusions regarding the impact of 20 mph on carbon emissions and air quality depend very strongly on which of these sources is used.

Steady-speed fuel consumption

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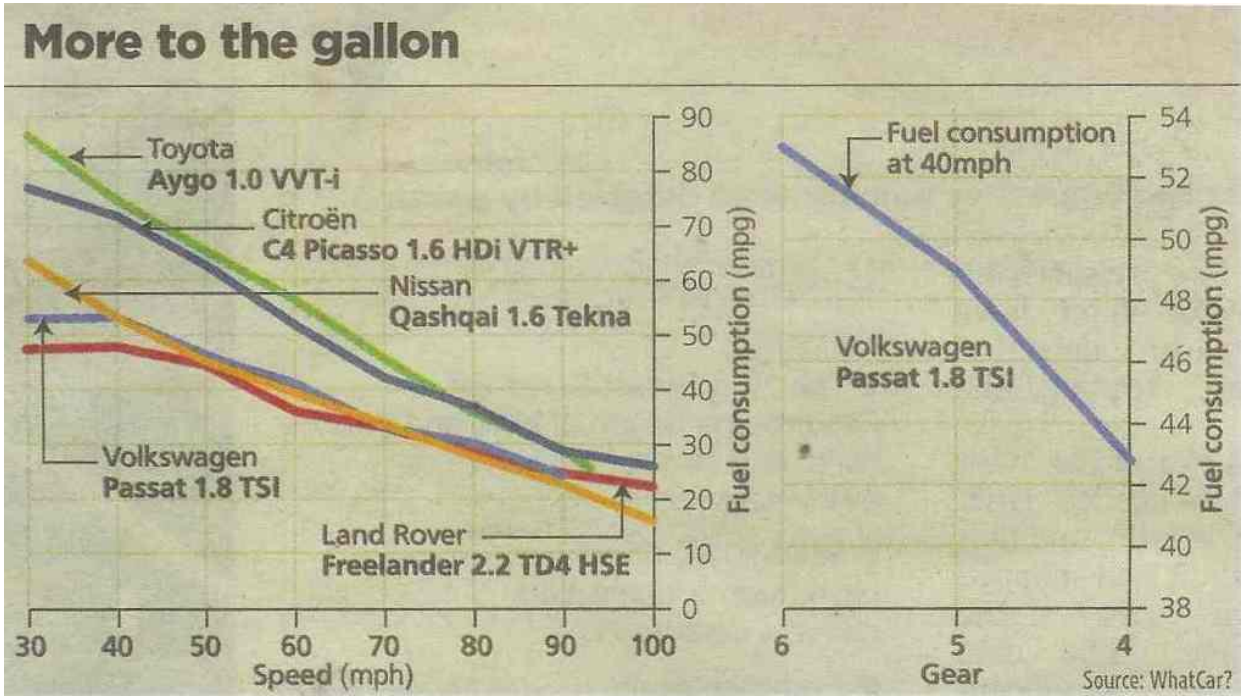
- **Optimum steady-state speed for fuel economy is a balance:**
  - With increasing speed:
    - Aerodynamic resistance increases as a square
    - Rolling resistance increases (also dependent on tyre pressure and load)
  - With decreasing speed:
    - Inefficiencies of the engine and drivetrain start to become dominant
    - Gear selection is crucial in determining fuel economy
- **Note:** As a rule of thumb, the optimum for smaller (internal combustion) engines is at a lower speed than for larger ones. The trend in car design is down-sizing of engines.

Steady-speed fuel consumption



Source: The Times, June 2008

Peter De Nayer, a former AA fuel efficiency expert:
"There is a huge misconception that the most fuel-efficient speed is around 55mph. The study shows that the slower you go with the vehicle running smoothly, the less fuel you will use." A Citroen C4 1.6 diesel achieved:

- 78 mpg at 30mph
- 100 mpg at 20 mph!

Steady-speed fuel consumption

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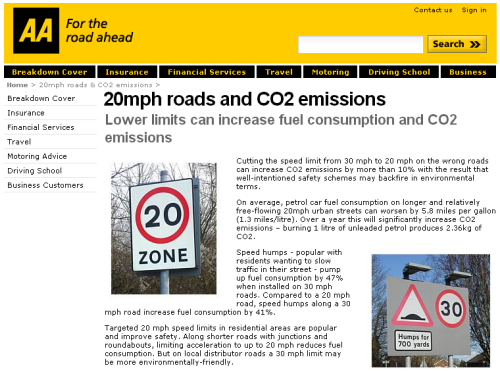
- ***AA – Steady speed fuel economy test results***
  - Steady 30mph (4th gear) = 58.15 mpg
  - Steady 20mph (3rd gear) = 52.3 mpg
  - *(average of small and medium sized petrol cars)*



The problem with using steady-speed fuel consumption

- **Journeys in built-up areas are far from being constant speed:**
  - A series of acceleration / variable speed cruise / deceleration
  - Acceleration uses far more fuel than steady-speed driving
  - Braking is the primary source of energy loss
  - *"Accelerations require a large input of energy, so any traffic schemes that involve stop/start driving and/or lots of braking and accelerating tend to produce high emissions."*

- **TRL - A summary of the evidence on the costs and benefits of speed limit reduction 2012**

Emission factor curves

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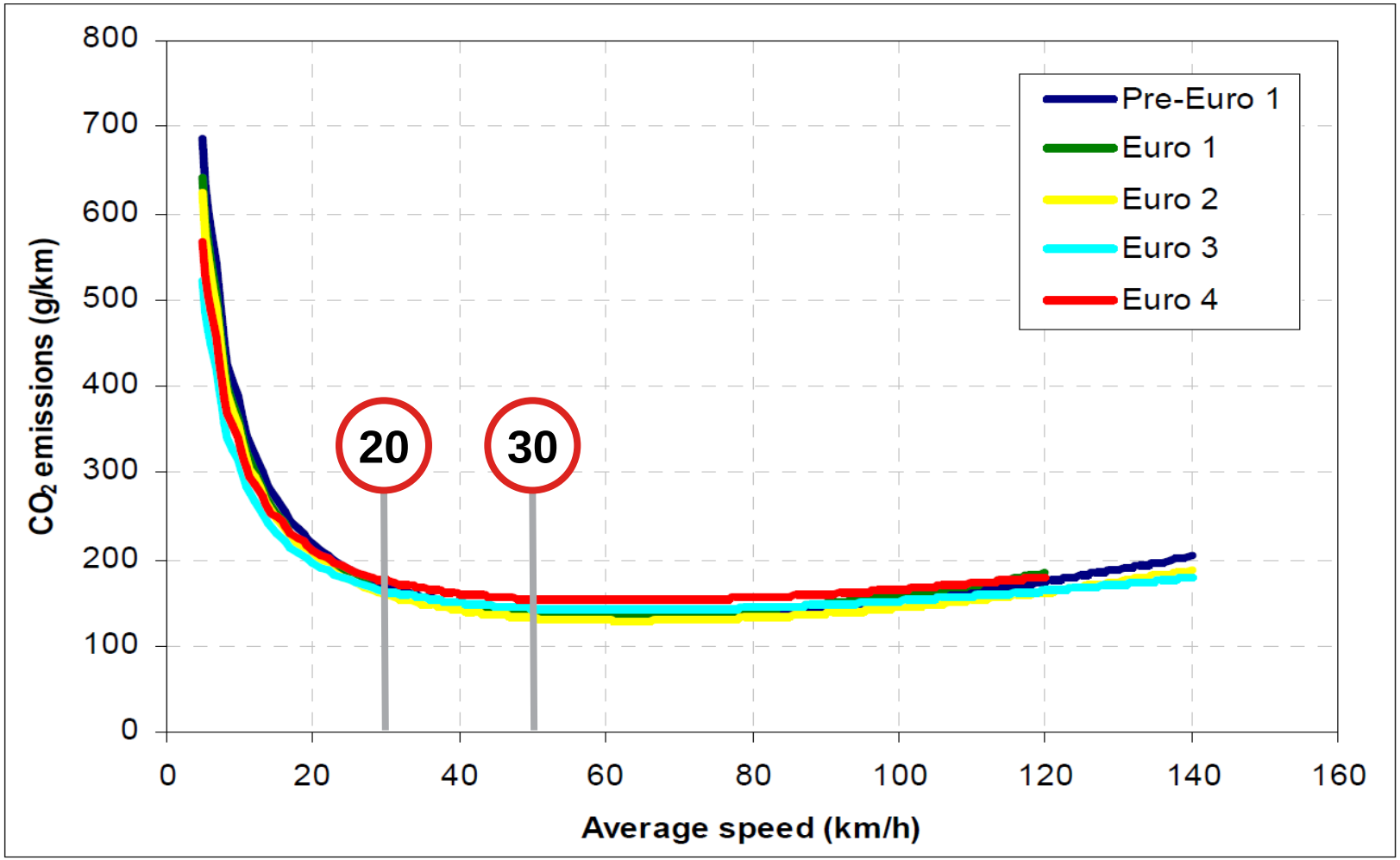
CO_2 emission factor - petrol car <1.4 litres



Source: TRL, Emissions factors 2009: Report 3 – exhaust emissions factors for road vehicles in the United Kingdom

Emission factor curves

- **Emission factor curves**
  - Based on laboratory vehicle test cycles
    - Wide range of different tests and vehicles
    - Each test results in one data point (emissions vs. average speed)
  - Allow estimates of HC, CO, NOx and fuel consumption (CO_2) to be made based on:
    - Vehicle type (incl. fuel / engine size and type / emissions standard)
    - Road type (urban / rural / motorway)
    - Average speed
  - Designed for inventories and estimating average emissions over a road network
  - Used in the DfT Local Authority Carbon Tool and Defra's Emission Factor Toolkit

Emission factor curves

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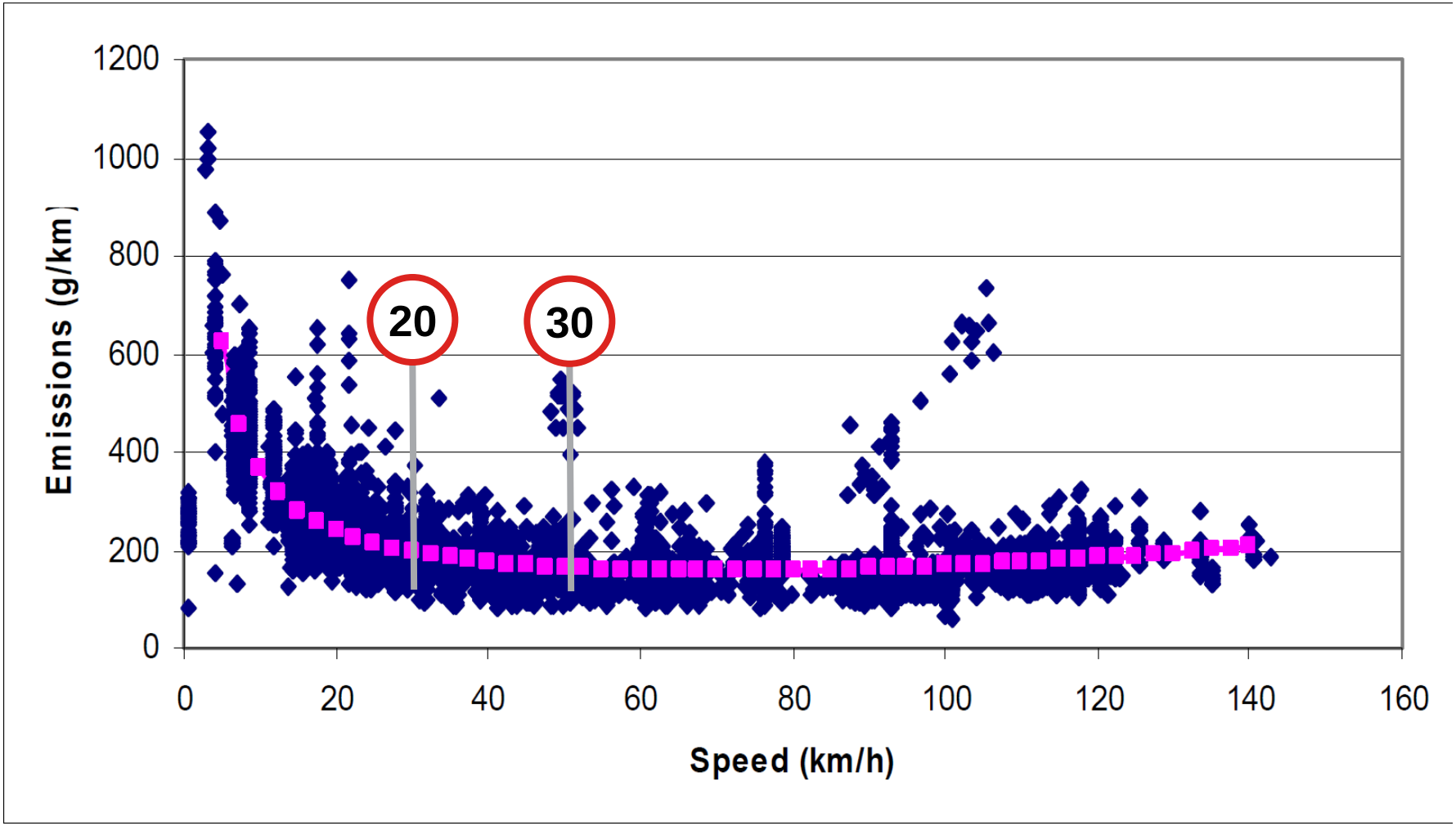
All CO_2 emissions factors for medium petrol cars



Source: TRL, Emissions factors 2009: Report 3 – exhaust emissions factors for road vehicles in the United Kingdom

Emission factor curves

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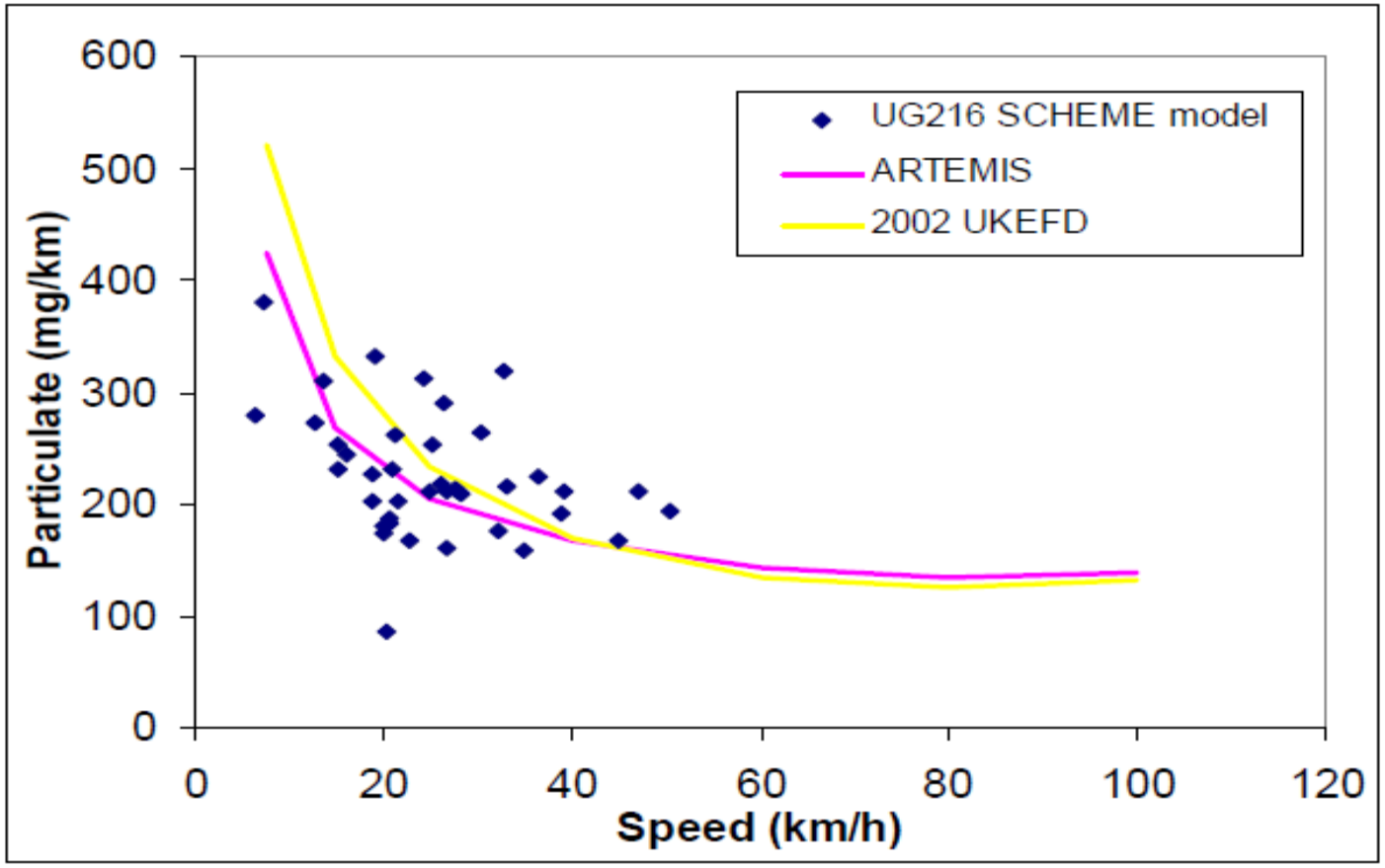
Particulate emissions from a Euro II rigid HGV



Source: Boulter et al., 2005

Emission factor curves

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- **The problem with using Emissions Factor Curves**
  - ***DfT:*** *Emissions factors curves, which show higher emissions at lower traffic speeds and upon which arguments against low speed limits are sometimes based, look at traffic streams travelling at particular average speeds. The higher emissions at lower speeds are a consequence of intermittent progress and overall driving behaviour, and have little to do with the speed limit.*
  - For **minor urban roads** average speeds are <u>currently</u> 17 – 24 mph (based on DfT carbon tool model) – what average speeds might be expected with a 20 mph limit?
  - Cold start emissions (TRL: "could be a source of significant error"[1])
    - 22% of car journeys under 2 miles / 56% are under 5 miles
  - Driving style and gear selection variations result in a much larger variation in fuel consumption than the change in average speed

Source 1: TRL, Emissions factors 2009: Report 4 – a review of methodologies for modelling cold start emissions

Emission factor curves

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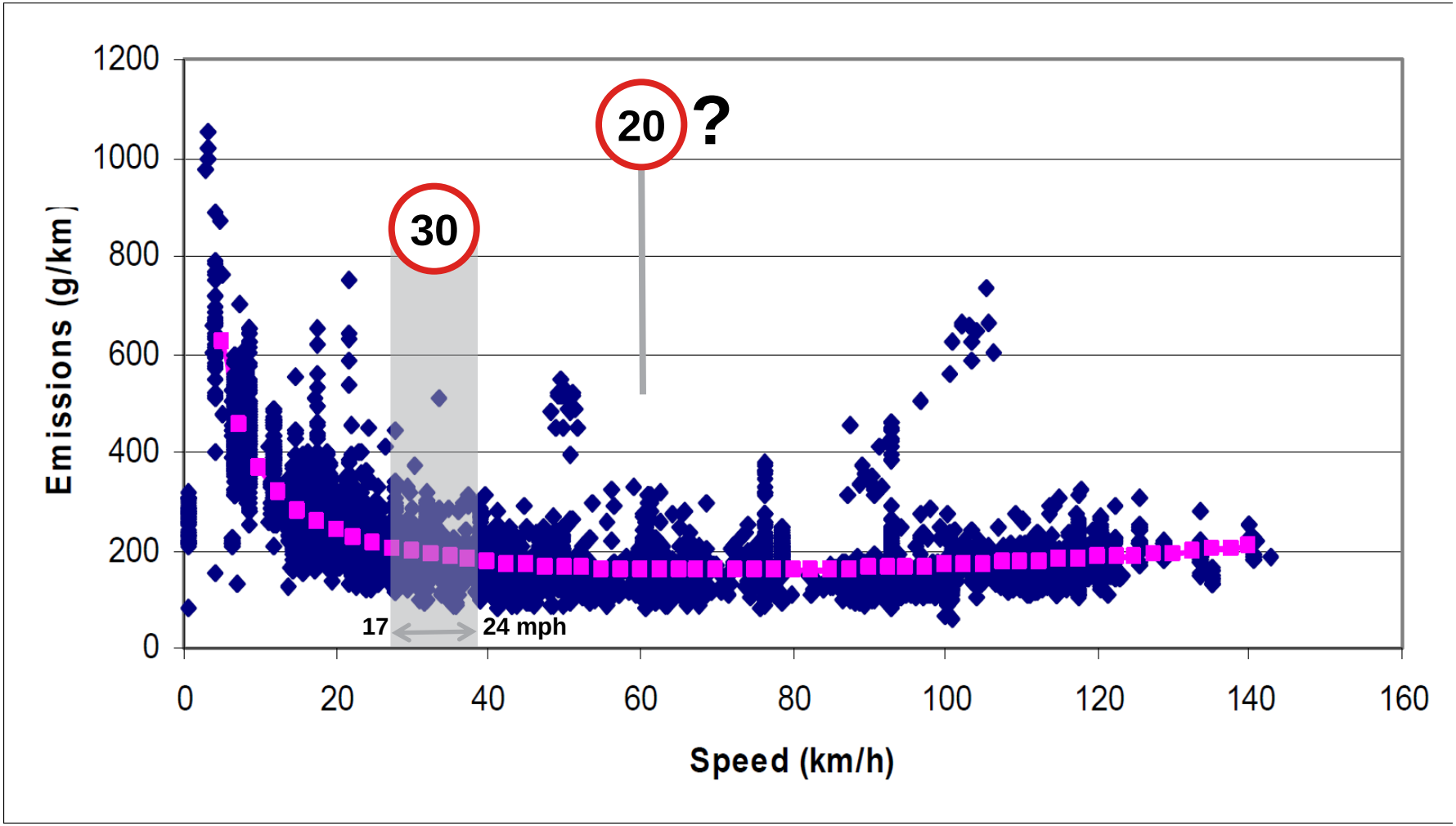
All CO_2 emissions factors for medium petrol cars



Source: TRL, Emissions factors 2009: Report 3 – exhaust emissions factors for road vehicles in the United Kingdom

Simulation modelling of vehicle emissions

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- Modelling based on engine data combined with speed / load inputs from drive cycles
- Simple models based on steady-state engine operation data, more advanced ones simulate transient emissions
- Enables prediction of emissions and fuel consumption for a given journey or test cycle to be made
- Examples include:
  - PHEM (**P**assenger car and **H**eavy duty vehicle **E**missions **M**odel)
  - VeTESS (**Ve**hicle **T**ransient **E**missions **S**imulation **S**oftware)
    - “specifically designed to calculate dynamic emissions, and thereby reaching higher accuracy than traditional emission simulation models including those using steady state engine maps”

Simulation modelling of vehicle emissions

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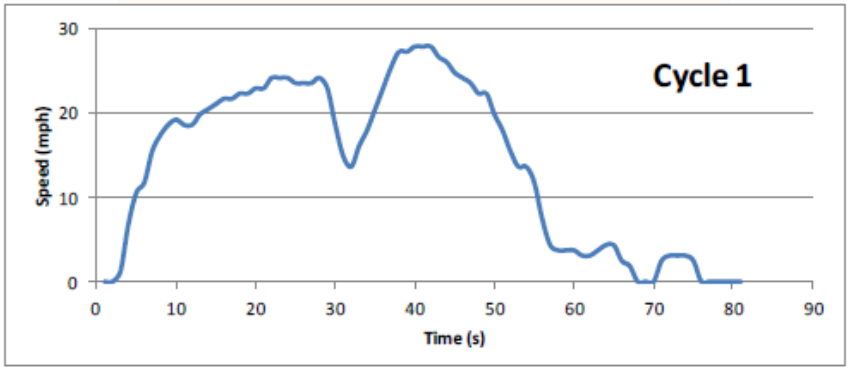
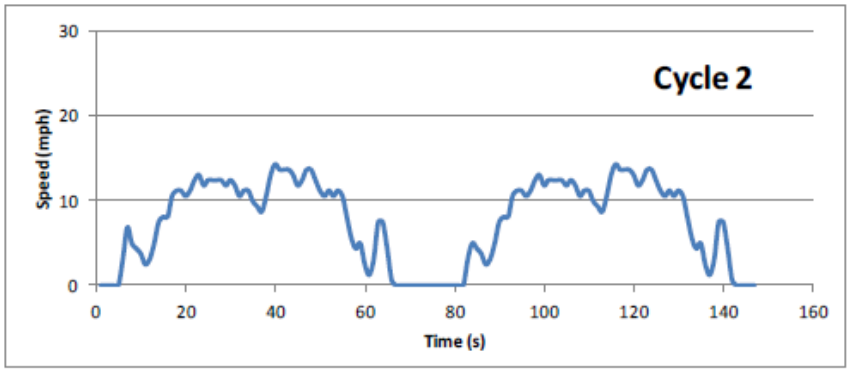
Results from 2012 TRL report (using PHEM model):



Medium speed cycle

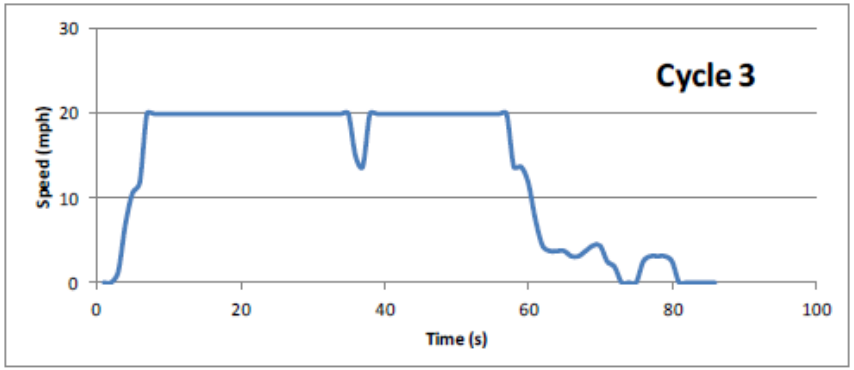
Average speed = 14.0 mph ; duration = 81 s



Slow speed cycle

Average speed = 7.7 mph ; duration = 147 s (+81%)

Petrol car: CO_2 = +49.9 % ; NOx = +44.5 % ;
Diesel car: CO_2 = +40.6 % ; NOx = +14.4 % ; PM = +59.3 %



Medium speed cycle

Average speed = 13.2 mph ; duration = 86 s (+6%)

Petrol car: CO_2 = +1.0 % ; NOx = -22.6 % ;
Diesel car: CO_2 = +7.5 % ; NOx = +9.6 % ; PM = +43.0%

Source: TRL, A summary of the evidence on the costs and benefits of speed limit reduction, 2012

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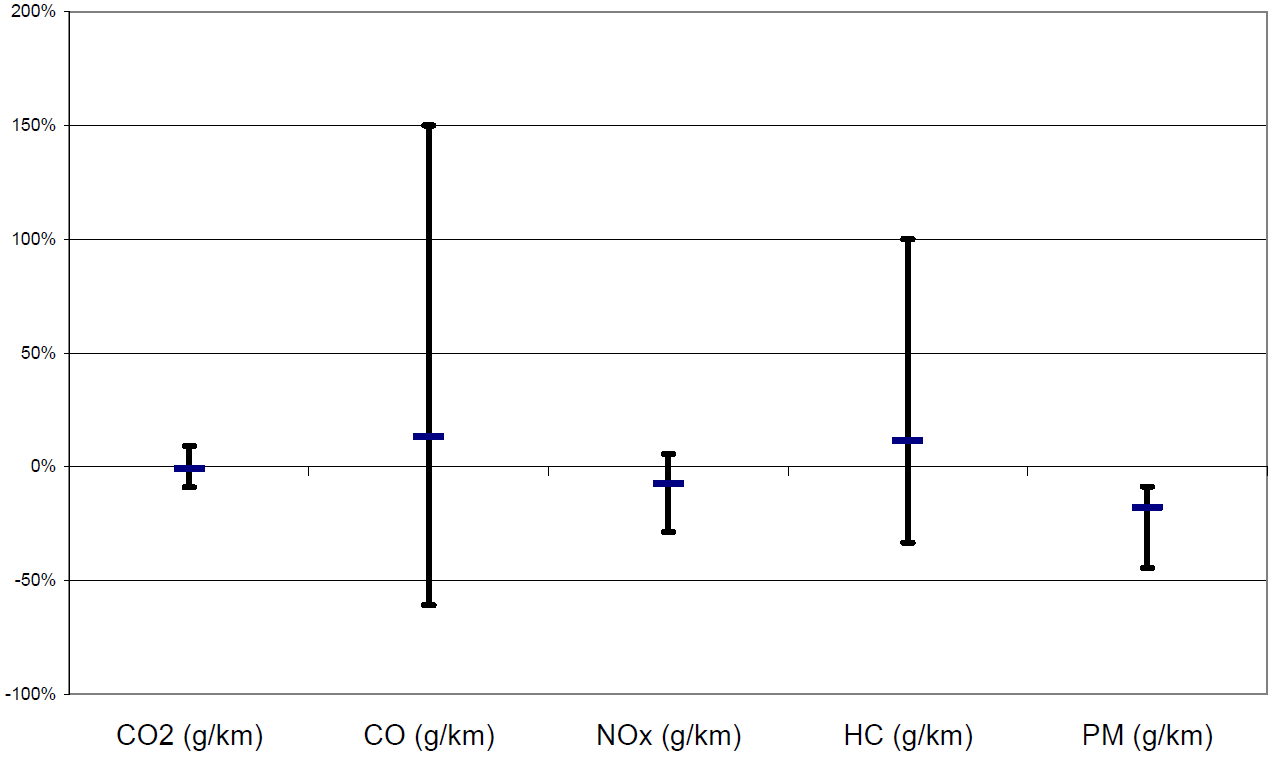
Results from 2011 VITO report (using VeTESS model):

- Real-world driving recorded for three different vehicles on six different cycles
- Cycles modified to limit top speed to 30 km/h (without changing accel/decel)
- Times increased to maintain original distances (4-6½ miles)
- Note: CO and HC absolute results very low. Model not sufficiently accurate



Source: Luc Int Panis Carolien Beckx and Steven Broekx – Impact of 30 km/h zone introduction on vehicle exhaust emissions in urban areas, 2011

Modal shift

- Primary motivation for wide-area 20 mph limits is to improve safety – particularly for pedestrians and cyclists
- encourage
- Increasing speeds and volumes of traffic have been strongly associated with decreasing levels of walking and cycling" (Jacobsen, Racioppi and Rutter, 2009).

Conclusions

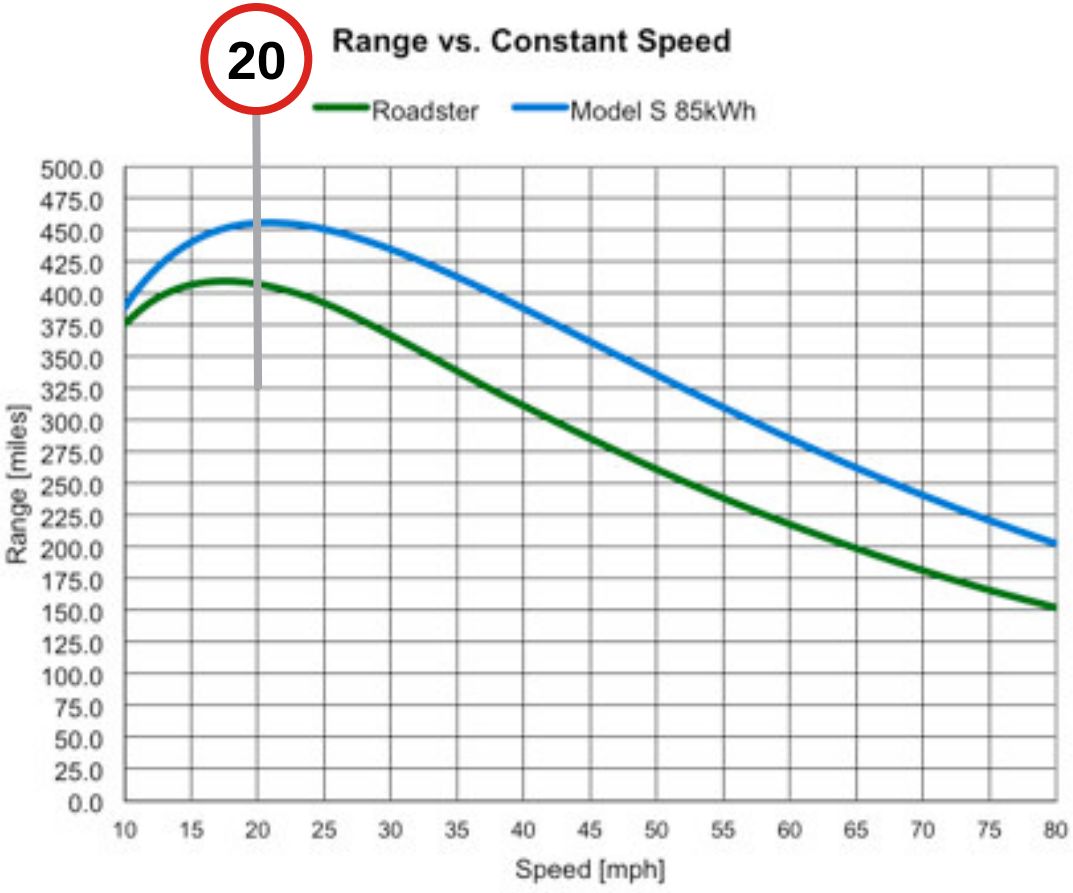
- 1. There is no direct relationship between fuel economy and posted speed limits – the impact of 20 mph speed limits depends on changing driver behaviour
- 2. Steady-speed results and “emissions factor” curves must be used with care
- 3. **IF** the reason to introduce 20 mph limits is to:
  - encourage more walking and cycling
  - encourage slower, smoother, more considerate driving

  THEN it seems likely that this should result in a reduction in carbon emissions and quite possibly NOx and PM.

“*In principle, driving more slowly (at a steady pace) will always save fuel and carbon dioxide emissions unless a quite unnecessarily low gear is being used. The underlying arguments are that moving a vehicle at a lower speed requires less power, and that avoiding unnecessary acceleration and braking saves energy.*” *Department for Transport*

But what about electric cars???

- According to Tesla Motors, the most efficient constant speed for their fully electric vehicles is about 20mph!



Source: http://www.teslamotors.com/blog/model-s-efficiency-and-range

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