



Ricardo-AEA

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

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4th Annual 20mph Conference

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- **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

- **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**

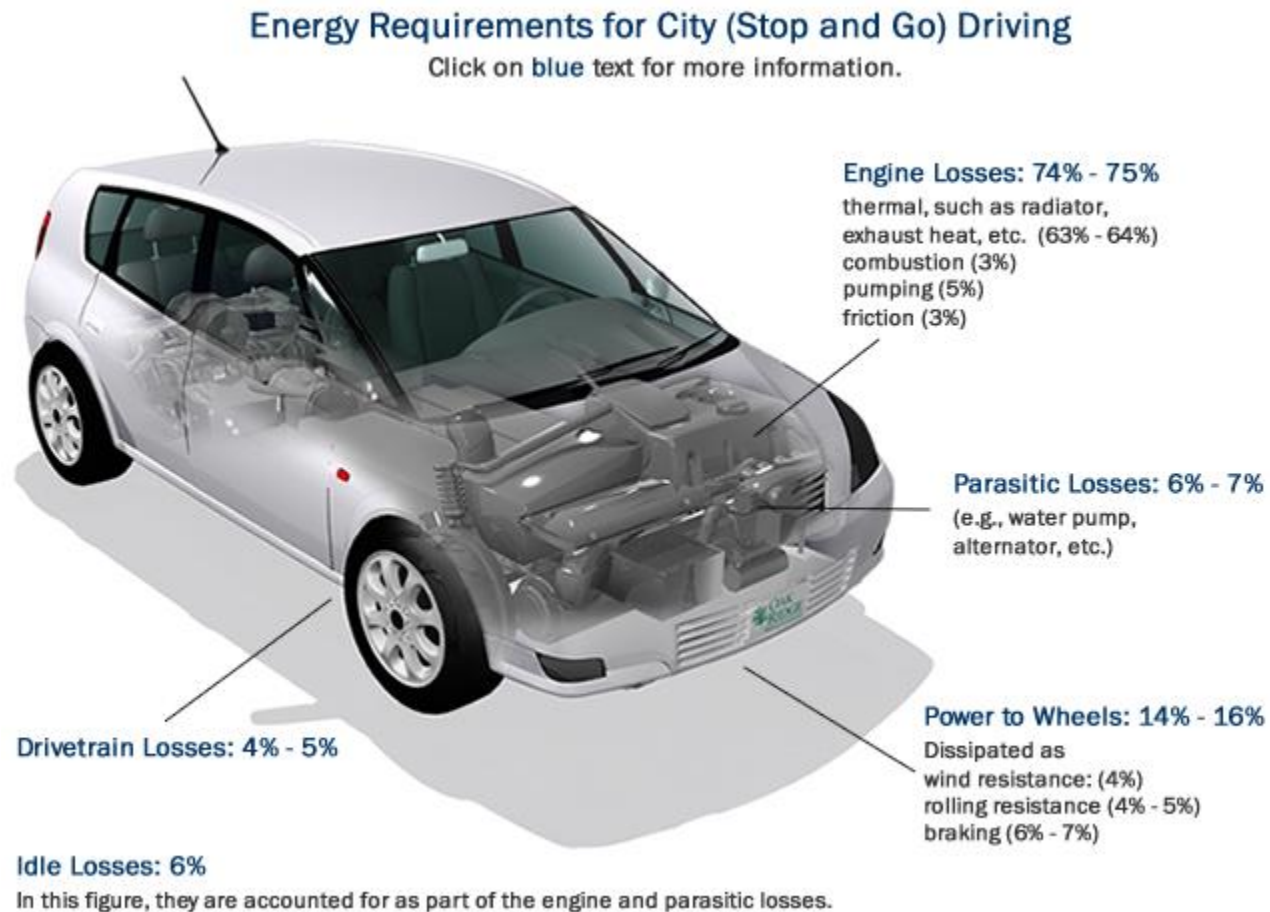
The impact of 20 mph limits on carbon emissions and air quality

- 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



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>

- **AA** – “Cutting the speed limit from 30 mph to 20 mph on the wrong roads can increase CO₂ emissions by more than 10%”
- **RAC** - “According to the Highways Agency’s figures, at 30mph average CO₂ 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 CO₂ 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

The screenshot shows the AA website interface. At the top, there is a navigation menu with links for Breakdown Cover, Insurance, Financial Services, Travel, Motoring, Driving School, and Business. Below the menu, the article title is "20mph roads and CO2 emissions" with a sub-headline "Lower limits can increase fuel consumption and CO2 emissions". The article text includes: "Cutting the speed limit from 30 mph to 20 mph on the wrong roads can increase CO2 emissions by more than 10% with the result that well-intentioned safety schemes may backfire in environmental terms." and "On average, petrol car fuel consumption on longer and relatively free-flowing 20mph urban streets can worsen by 5.8 miles per gallon (1.3 miles/litre). Over a year this will significantly increase CO2 emissions – burning 1 litre of unleaded petrol produces 2.36kg of CO2." There are also images of a 20 mph zone sign and a speed hump sign.

Transport Research Laboratory
Creating the future of transport



CLIENT PROJECT REPORT CPR1398

A summary of the evidence on the costs and benefits of speed limit reduction

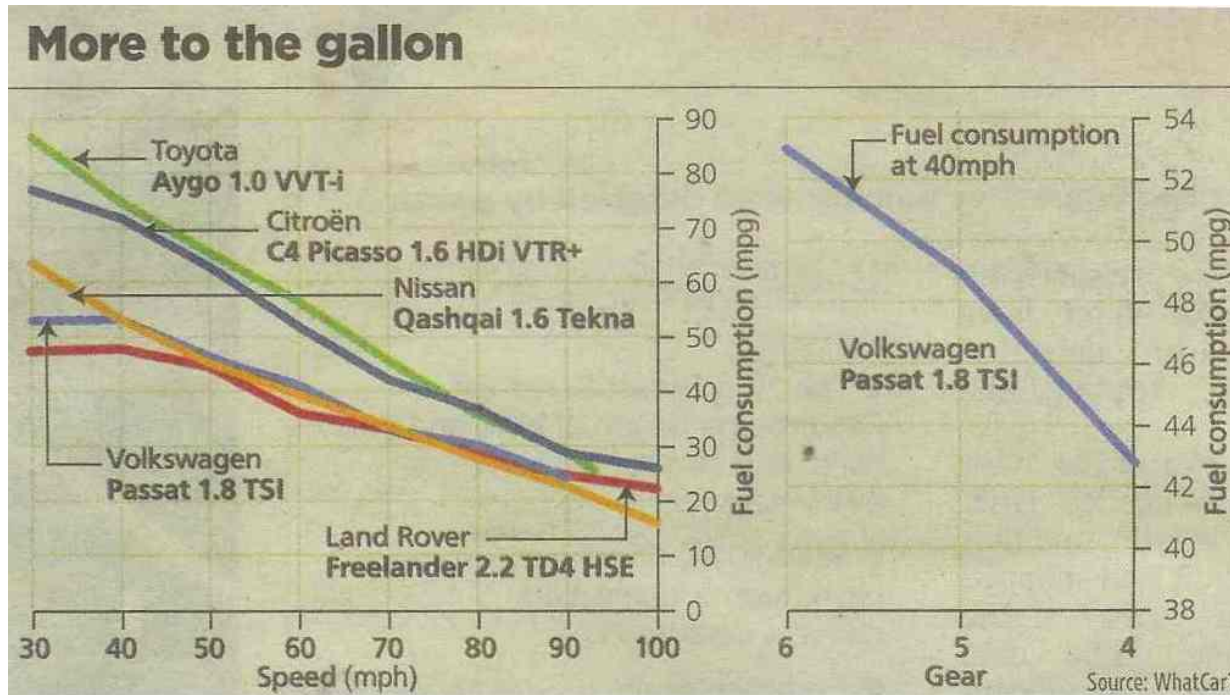
B Lawton, S Charman, N Kinnear, M Ainge, T Barlow, P Emmerson, M Jones and K Fernandez-Medina

- *"It is unlikely that imposing strict speed limits in urban areas has a significant influence on emissions of NOx or CO₂."* (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?

- **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.

- **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.



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!

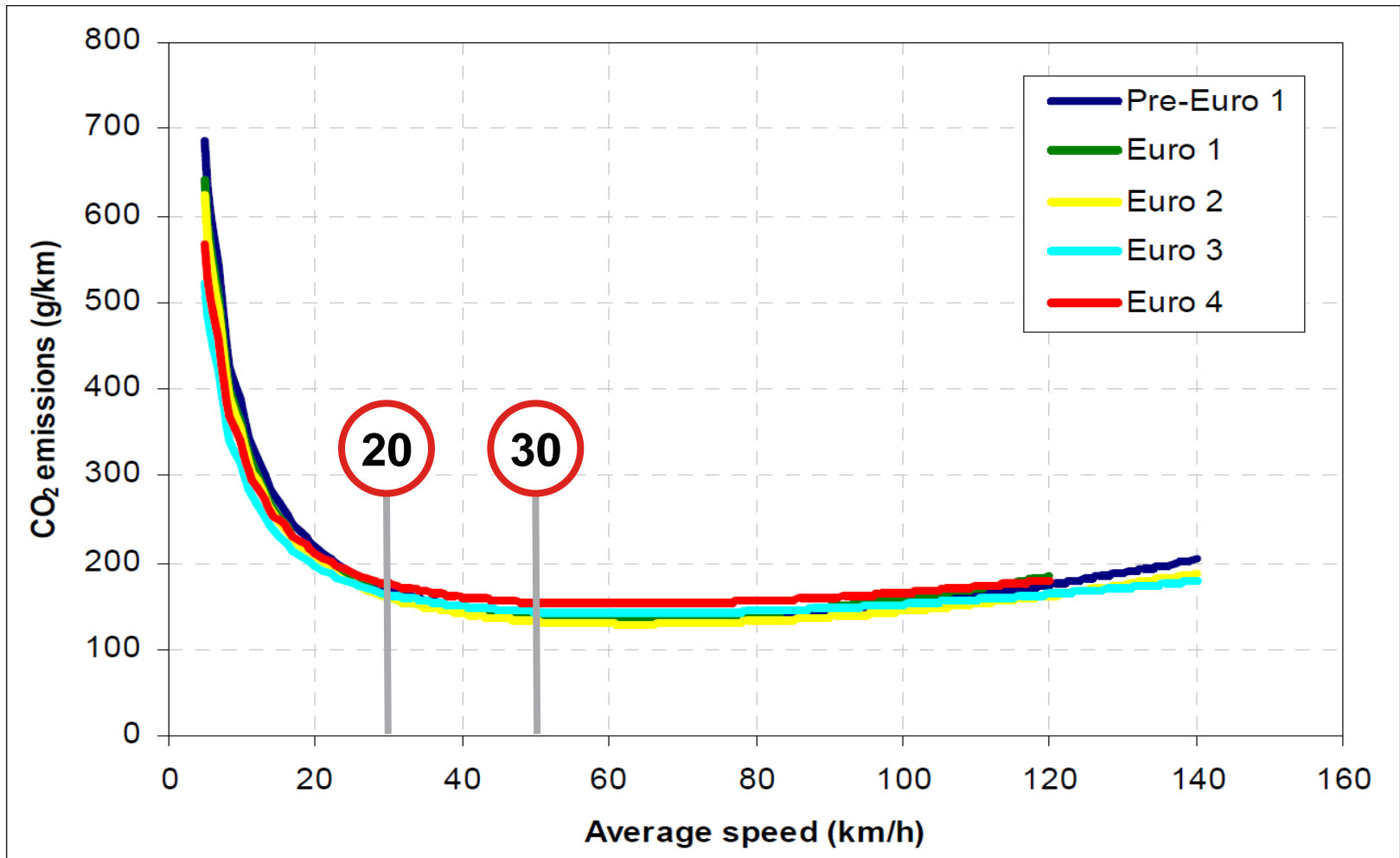
- **AA – Steady speed fuel economy test results**
 - Steady 30mph (4th gear) = 58.15 mpg
 - Steady 20mph (3rd gear) = 52.3 mpg
 - (average of small and medium sized petrol cars)

The screenshot shows the AA website interface. The main article title is "20mph roads and CO2 emissions". The sub-headline reads "Lower limits can increase fuel consumption and CO2 emissions". The article text includes: "Cutting the speed limit from 30 mph to 20 mph on the wrong roads can increase CO2 emissions by more than 10% with the result that well-intentioned safety schemes may backfire in environmental terms." It also states: "On average, petrol car fuel consumption on longer and relatively free-flowing 20mph urban streets can worsen by 5.8 miles per gallon (1.3 miles/litre). Over a year this will significantly increase CO2 emissions - burning 1 litre of unleaded petrol produces 2.36kg of CO2." Another section mentions: "Speed humps - popular with residents wanting to slow traffic in their street - pump up fuel consumption by 47% when installed on 30 mph roads. Compared to a 20 mph road, speed humps along a 30 mph road increase fuel consumption by 41%." A final section notes: "Targeted 20 mph speed limits in residential areas are popular and improve safety, along shorter roads with junctions and roundabouts, limiting acceleration to up to 20 mph reduces fuel consumption. But on local distributor roads a 30 mph limit may be more environmentally-friendly." There are two small images: one of a 20mph speed limit sign and another of a speed hump with a 30mph sign.

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

CO₂ emission factor - petrol car <1.4 litres

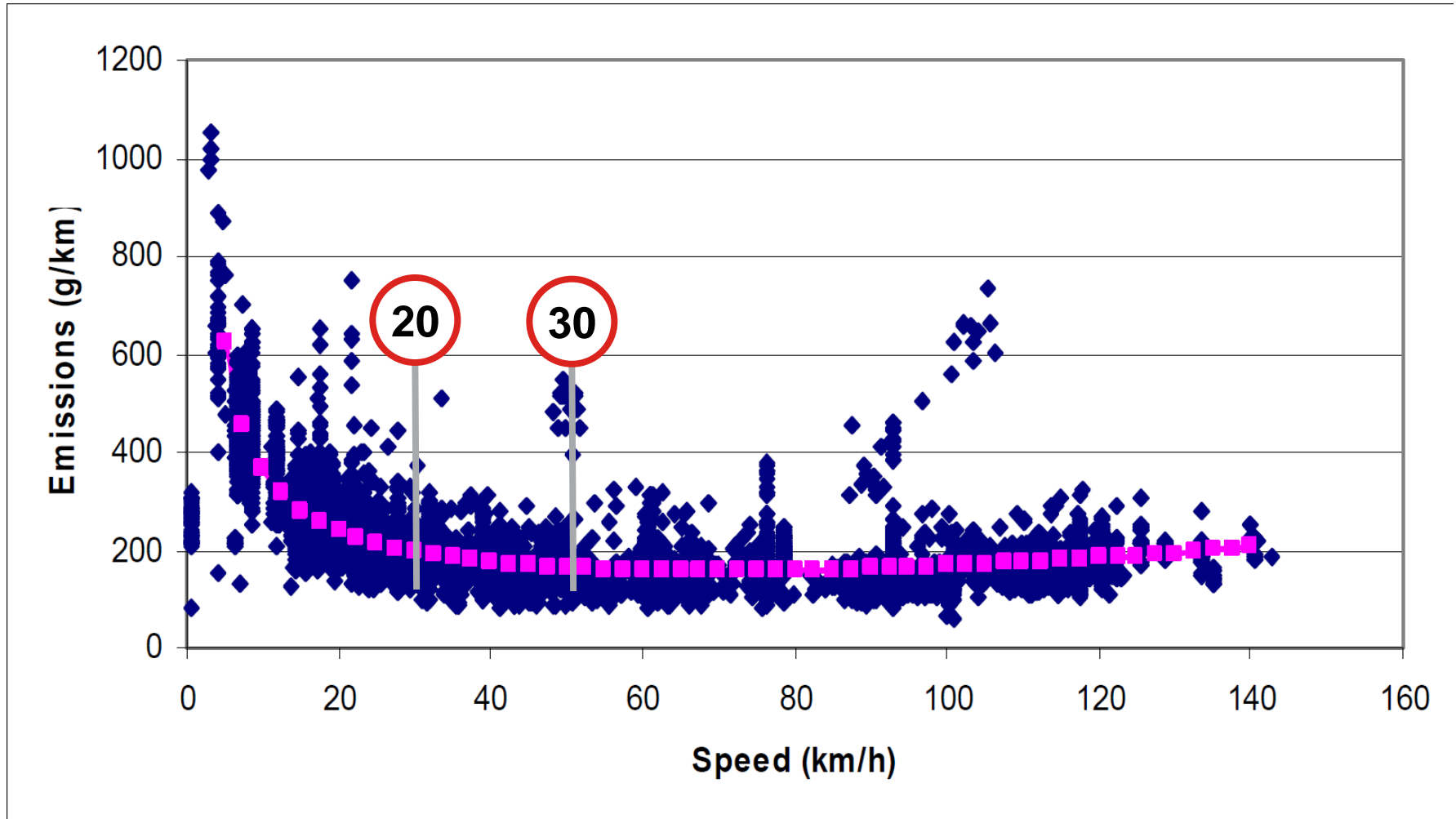


Source: TRL, Emissions factors 2009: Report 3 – exhaust emissions factors for road vehicles in the United Kingdom

- **Emission factor curves**

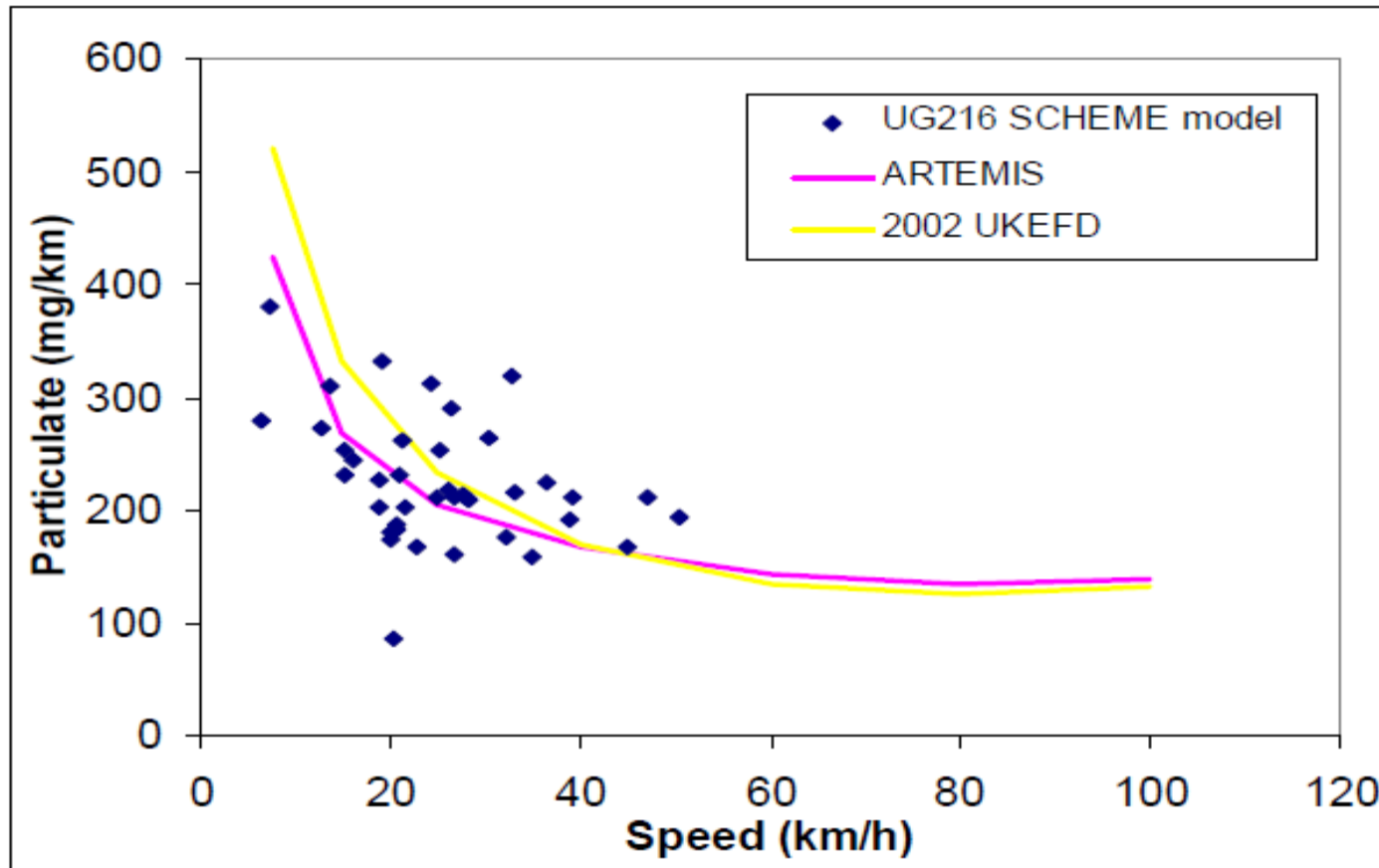
- Based on laboratory vehicle test cycles
 - Wide range of different tests and vehicles
 - Each test results in one data point (emissions vs. average speed)
- Allow estimates of HC, CO, NO_x and fuel consumption (CO₂) to be made based on:
 - Vehicle type (incl. fuel / engine size and type / emissions 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

All CO₂ emissions factors for medium petrol cars



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

Particulate emissions from a Euro II rigid HGV



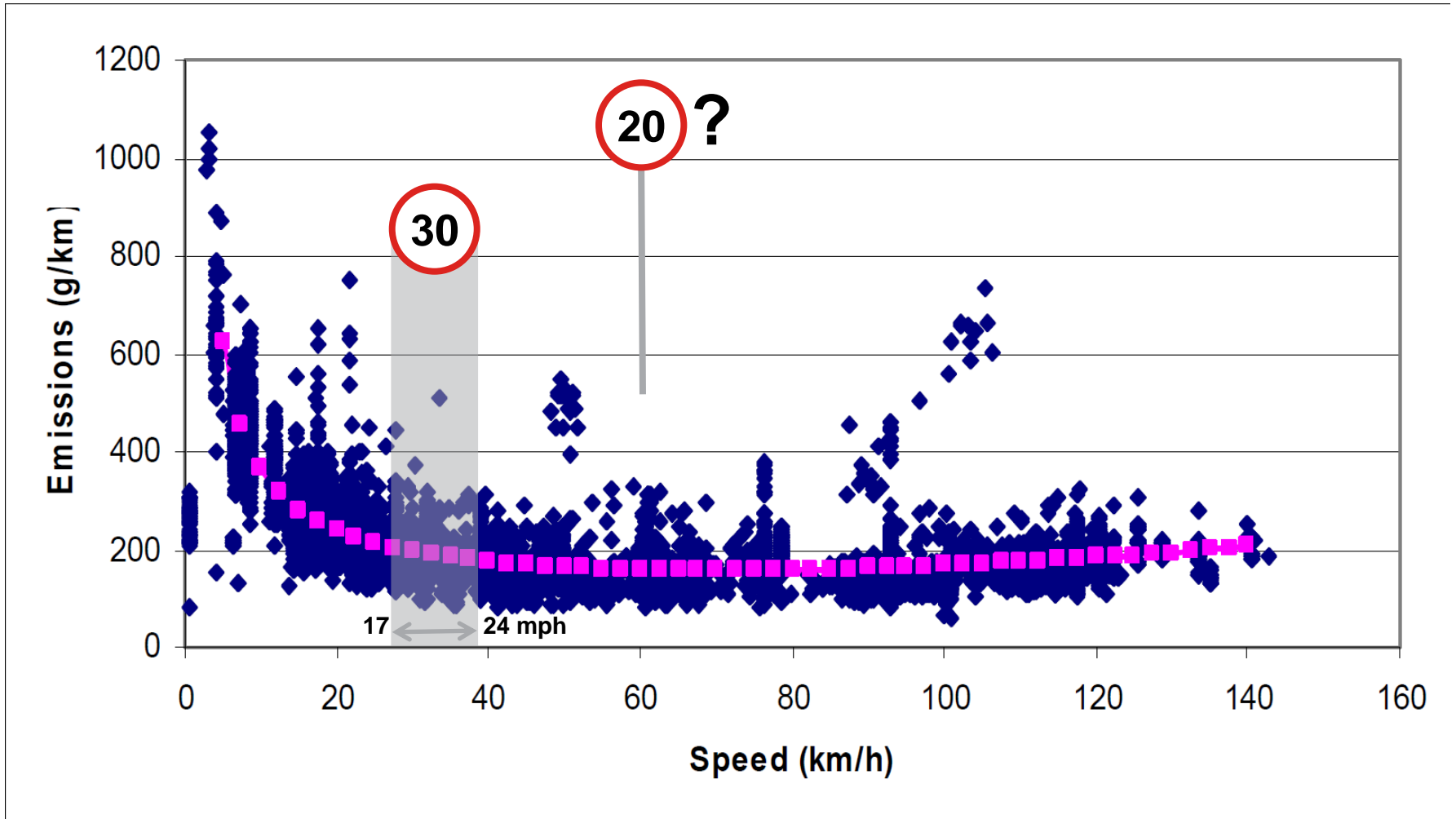
Source: Boulter et al., 2005

- **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 currently 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

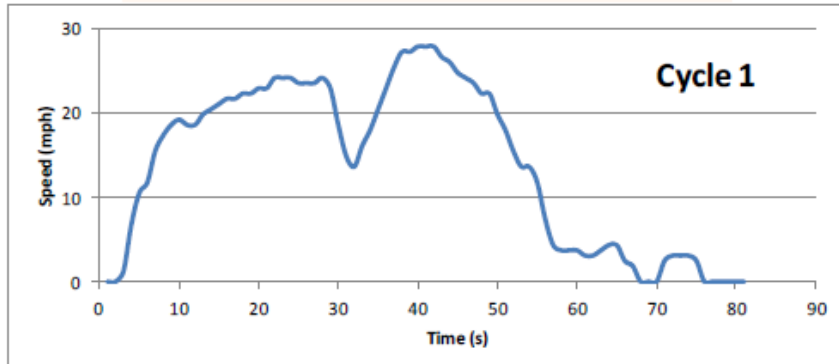
All CO₂ emissions factors for medium petrol cars



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

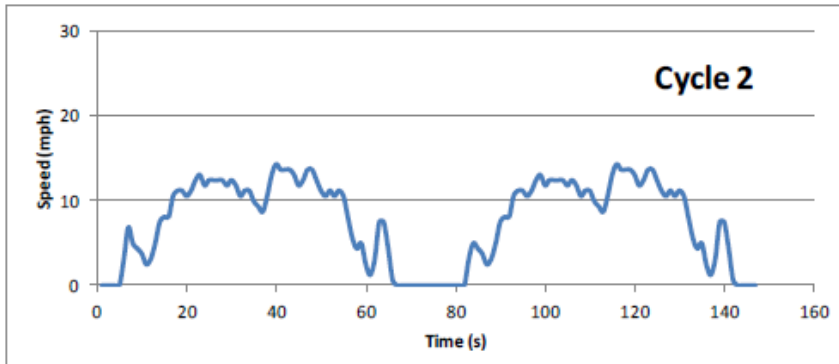
- Modelling based on engine data combined with speed / load inputs from drive cycles
- Simple models based on steady-state engine operation data, more advanced ones simulate transient emissions
- Enables prediction of emissions and fuel consumption for a given journey or test cycle to be made
- Examples include:
 - PHEM (**P**assenger car and **H**heavy duty vehicle **E**missions **M**odel)
 - VeTESS (**V**ehicle **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”

Results from 2012 TRL report (using PHEM model):



Medium speed cycle

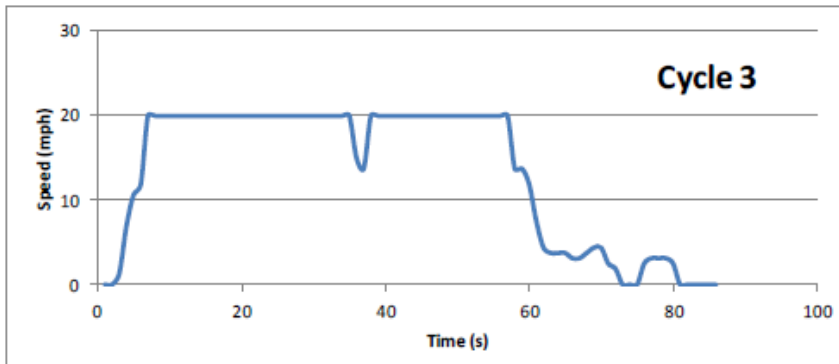
Average speed = 14.0 mph ; duration = 81 s



Slow speed cycle

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

Petrol car: CO₂ = +49.9 % ; NO_x = +44.5 % ;
Diesel car: CO₂ = +40.6 % ; NO_x = +14.4 % ; PM = +59.3 %



Medium speed cycle

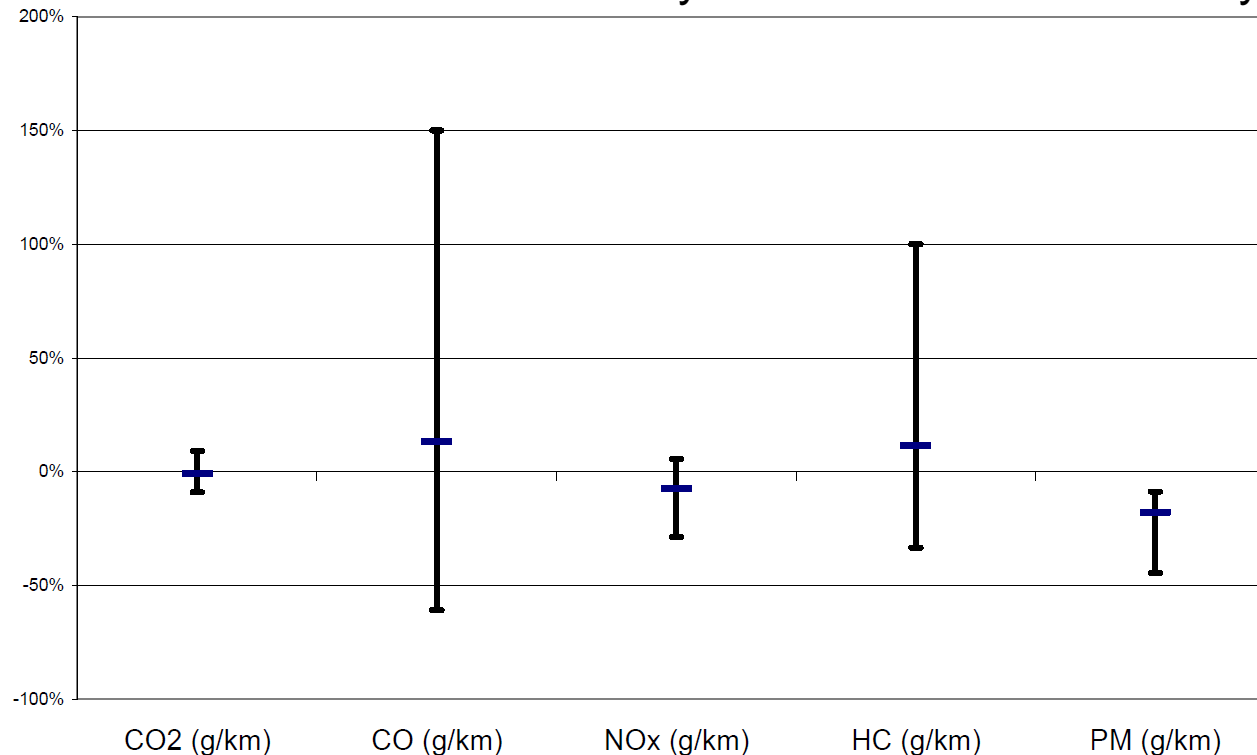
Average speed = 13.2 mph ; duration = 86 s (+6%)

Petrol car: CO₂ = +1.0 % ; NO_x = -22.6 % ;
Diesel car: CO₂ = +7.5 % ; NO_x = +9.6 % ; PM = +43.0%

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

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

- 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).

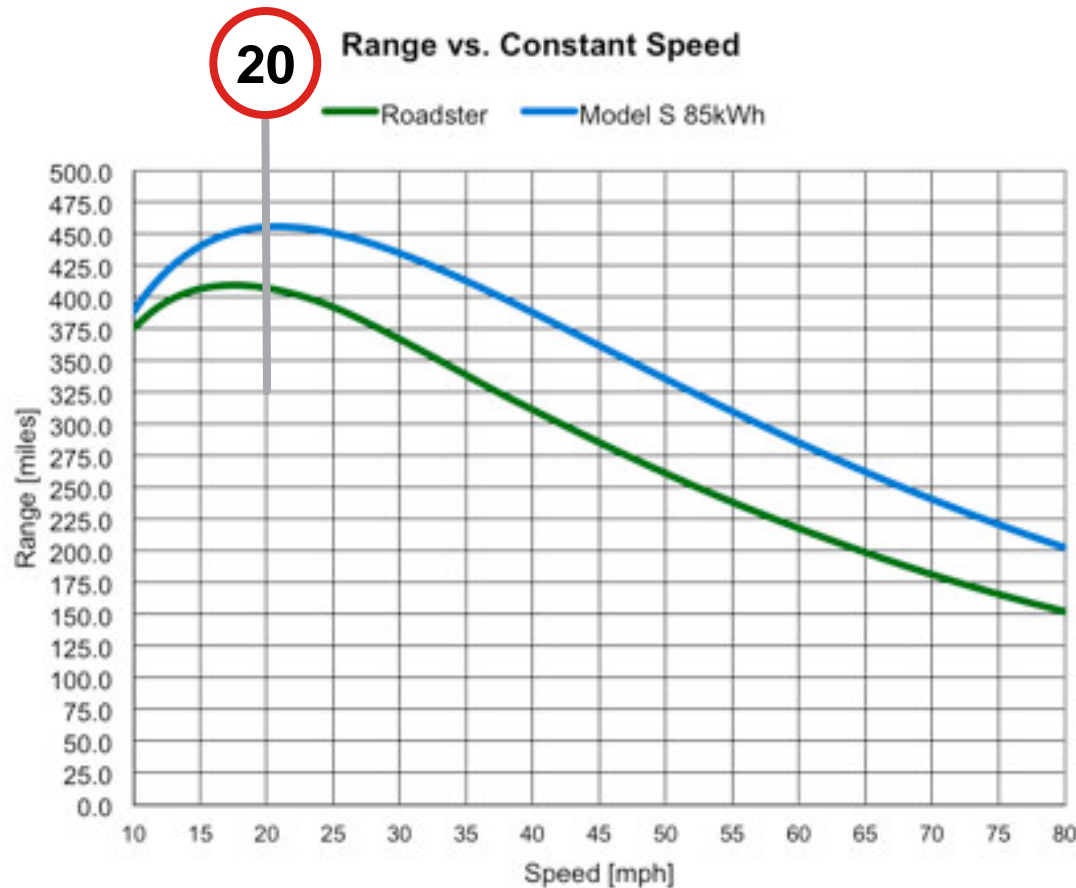
- 1. There is no direct relationship between fuel economy and posted speed limits – the impact of 20 mph speed limits depends on changing driver behaviour
- 2. Steady-speed results and “emissions factor” curves must be used with care
- 3. **IF** the reason to introduce 20 mph limits is to:
 - encourage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