Development of the GAZ application

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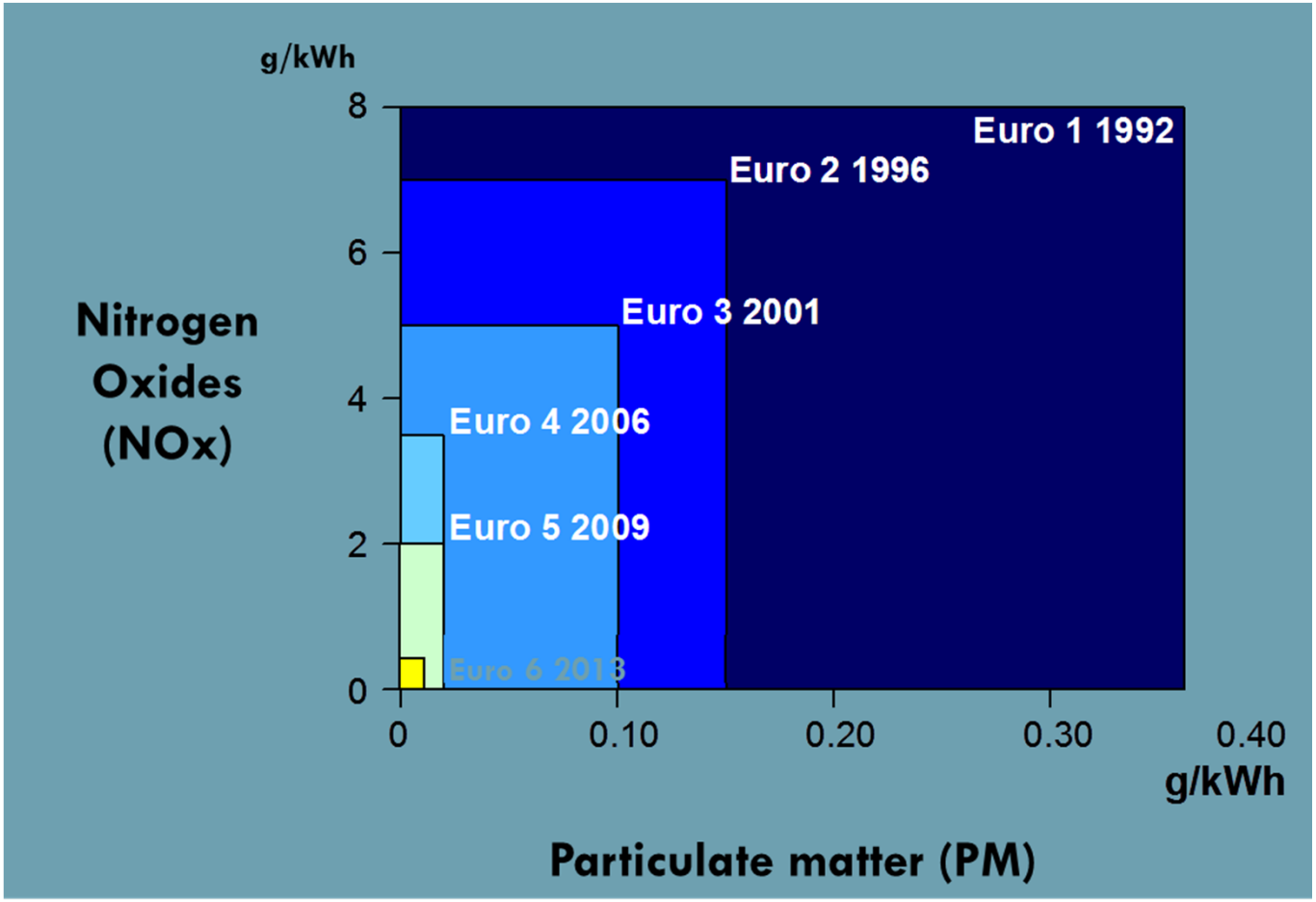
Urban freight transport

- Urban rubber wheel distribution is an essential piece of the freight chain
  - A simple mode change is not possible
  - EV's only a temporary fix – behave energy friendly
  - Basically left with: Do what you do, but do it better…
- The role of the GAZ application
  - Focus on behaviour
  - ECO driving has shown potential, academically proven
  - Could be seen as "Continual ECOdriving" that affects profitability
  - "Recycle" freight industry waste data

Why GAZ

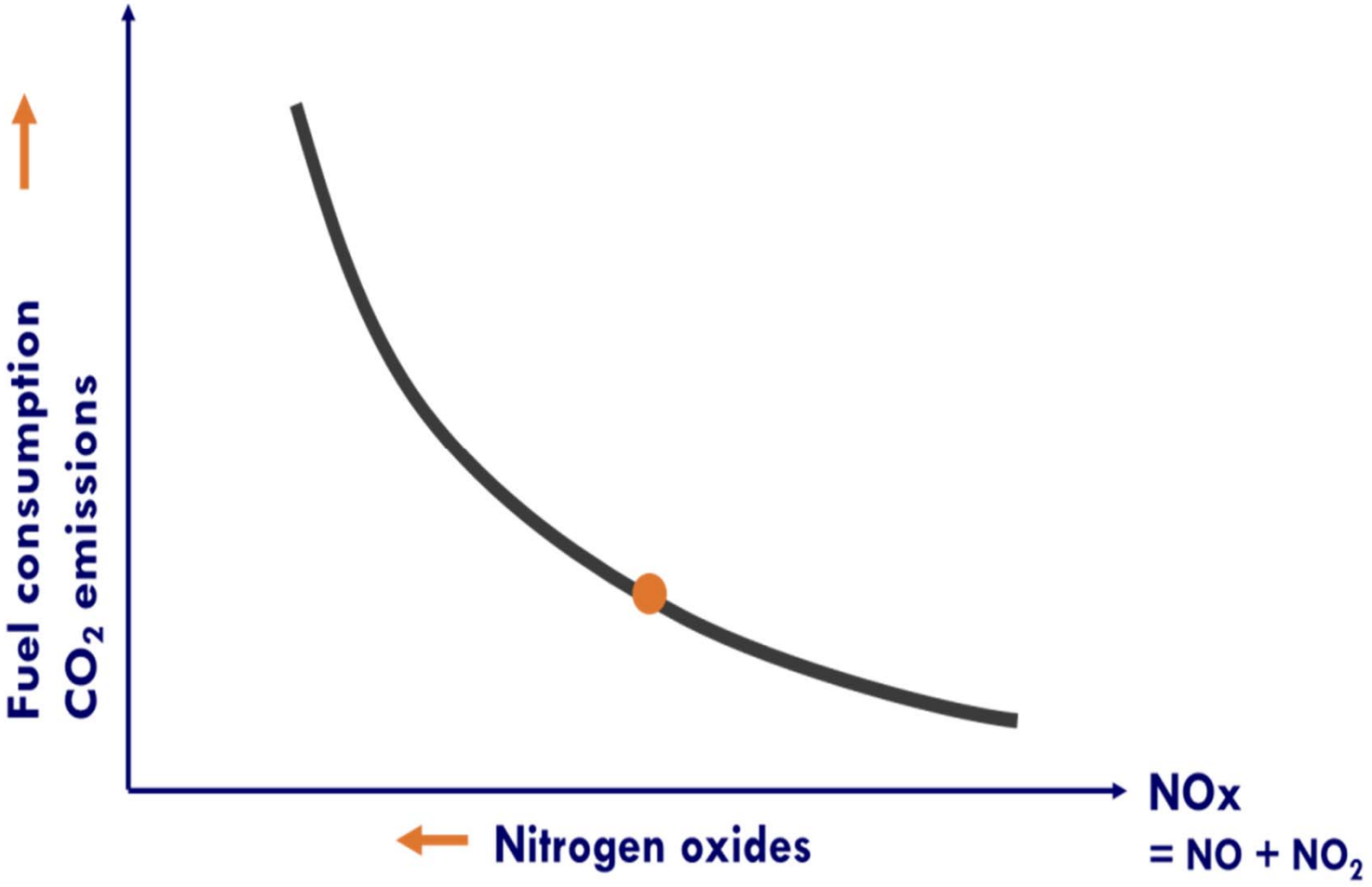
- Terjes graph – The Euro emission failure in congested areas
  - Euro emission standard has not had the anticipated effect
  - A phenomenon known as cycle-beating
    - Documented back in 1998 (Kågeson)
  - The PM filter – offset balance between NO and NO_2
  - CO_2 not regulated by the Euro emission standard
  - Still a long time till every truck will be Euro 6

Euro emission standards

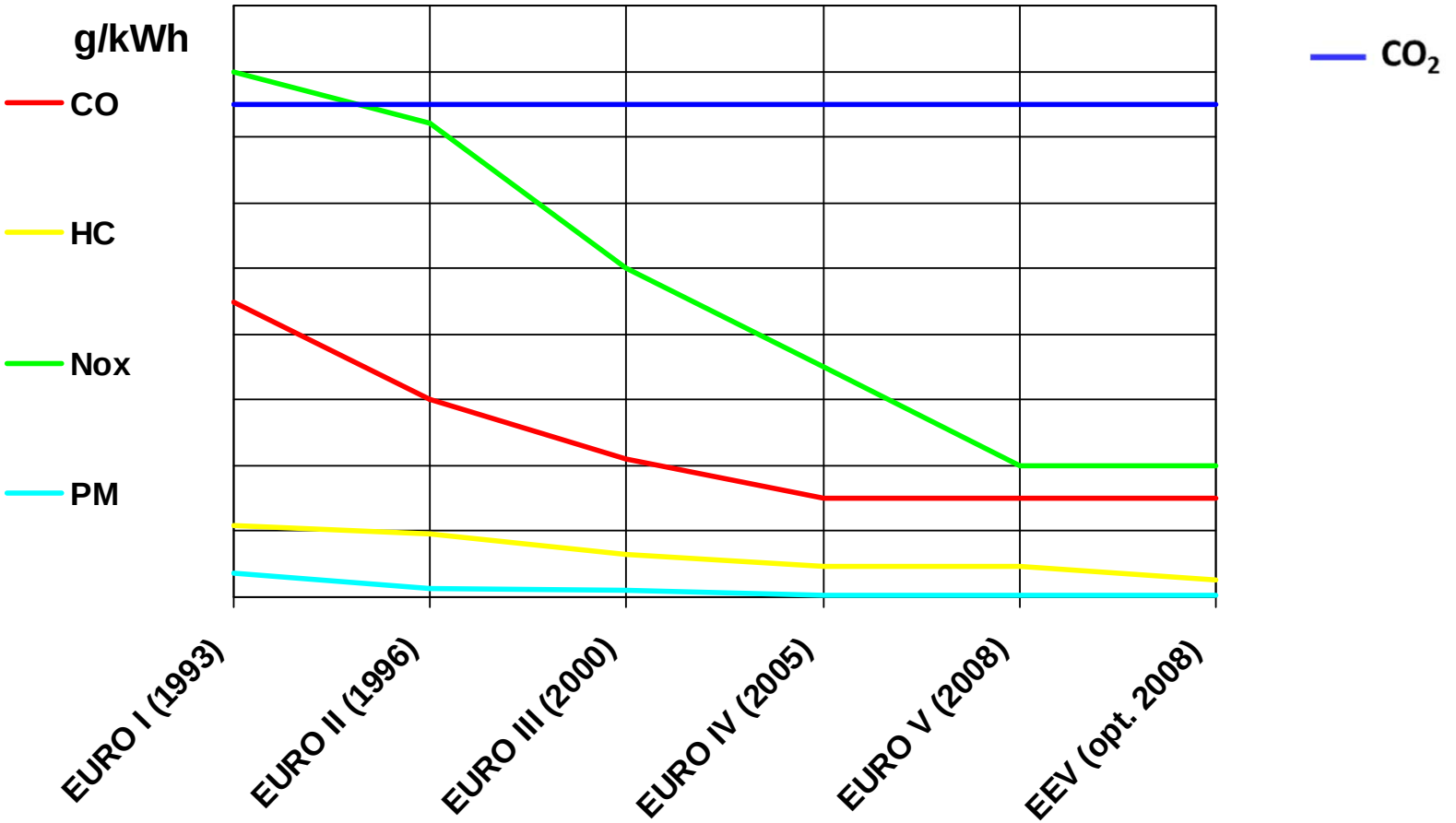


Note HDV Euro norm should be roman numerals

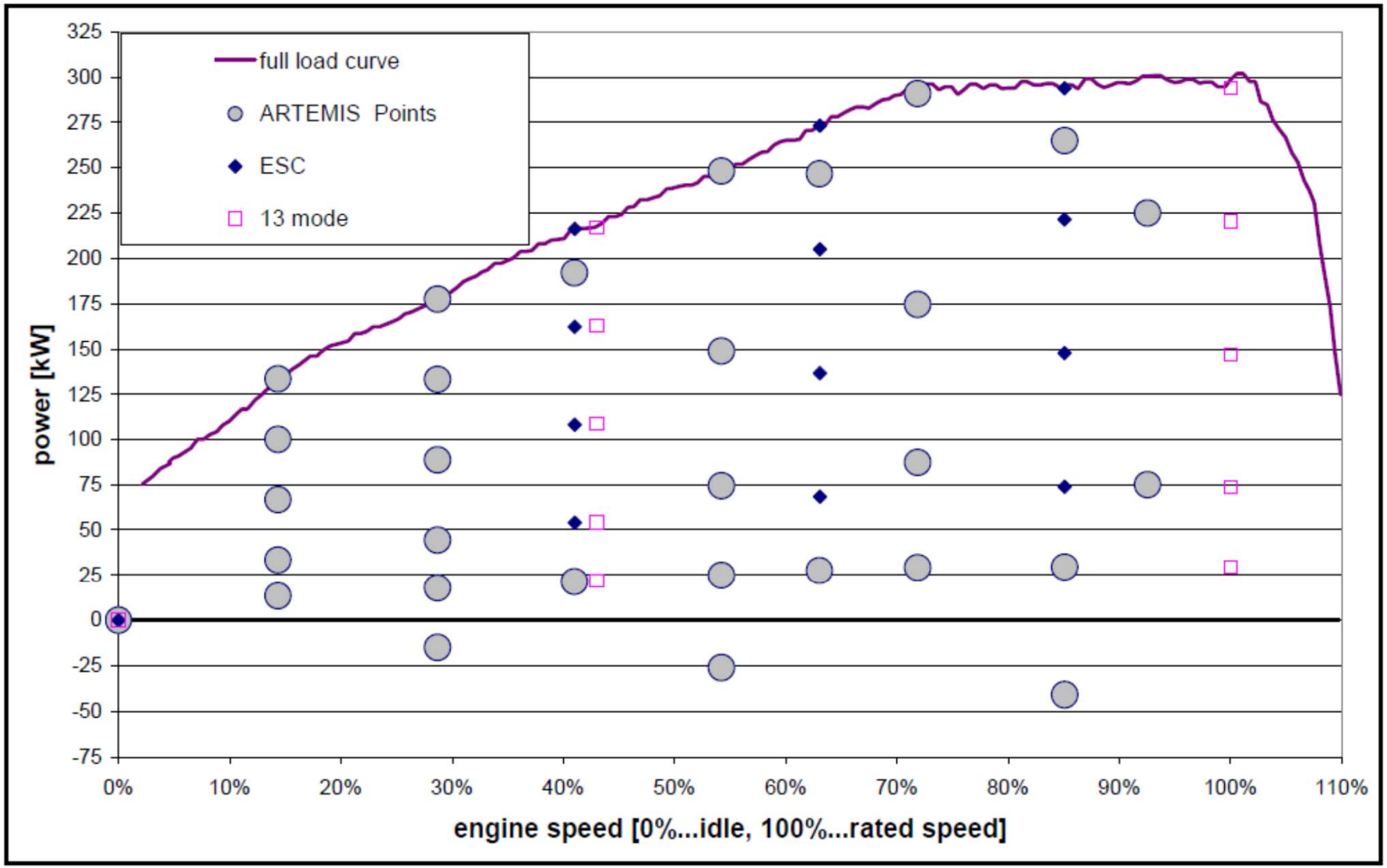
Motivation for cycle-beating



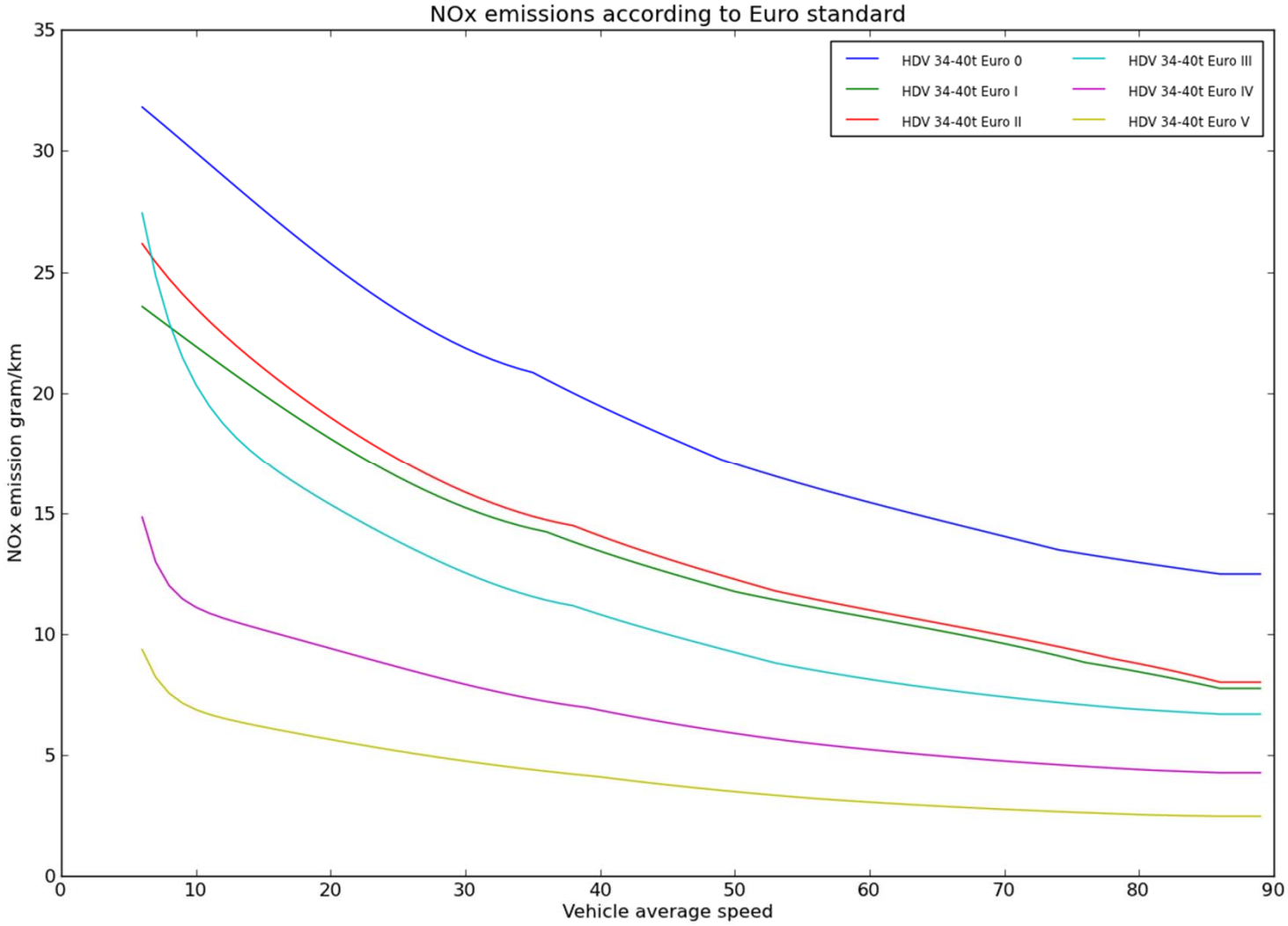
Emissions and energy



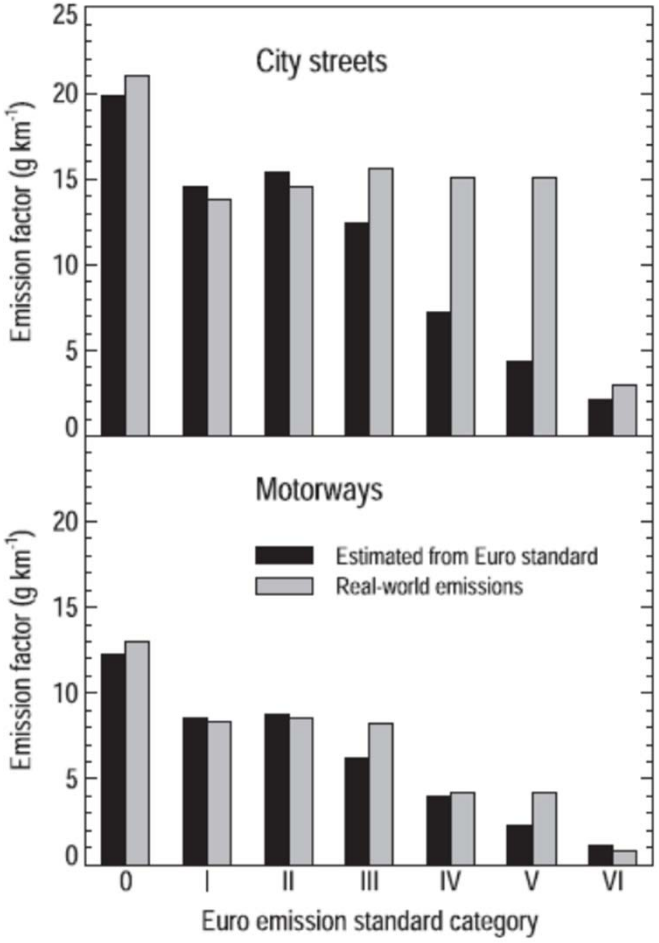
The NEC (ECE+EUDC) measurement points



Evidence from the ARTEMIS project



The result of cycle-beating



First evidence in 1998 – Transport and environment, Kågeson

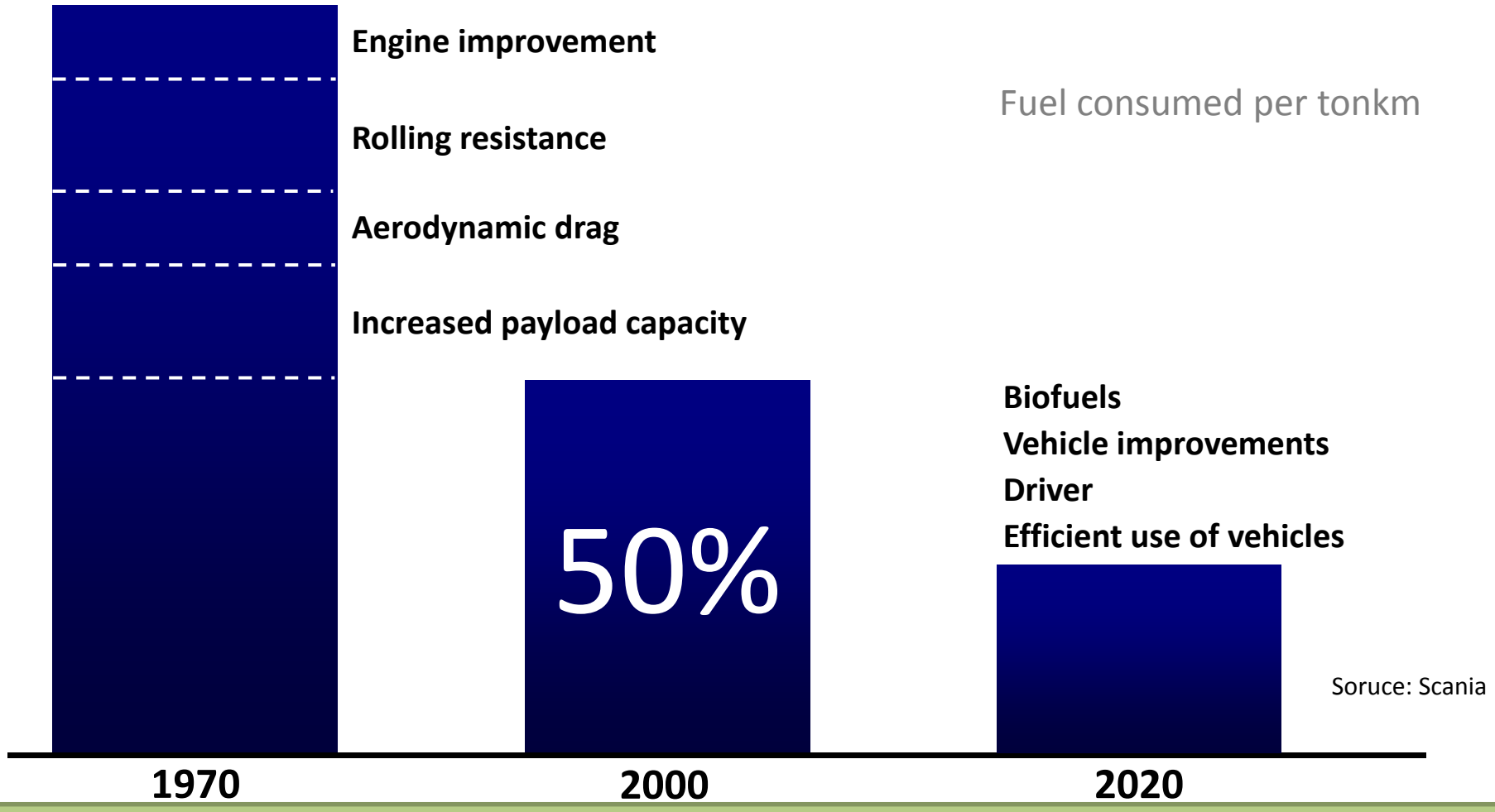
HDV manufacturers in violation of clean air act $83.4 mill

Introduction of equivalent of NTE regulation in 2013

What is the alternat

Source:
Velders, Geilenkirchen and de Lange: "Higher than expected NOx emission from trucks may affect attainability of NO2 limit values in the Netherlands". *Atmospheric Environment 45 (2011) 3025-3033.*

Fuel efficiency



In-vehicle technology

- The ECU
  - Made cycle beating possible
  - A unique way to access data from the engine
- Using engine-maps
  - Foundation for state of the art emission tools – PHEM & VERSIT+
  - Created on the basis of measurements, possibly PEMS
  - Emissions as function of engine load and engine speed
- FMS (Fleet Management System) standard
  - Secure and standardised way to get data from the internal vehicle network
  - 7 HDV manufacturers
  - Monitoring performance in near real-time

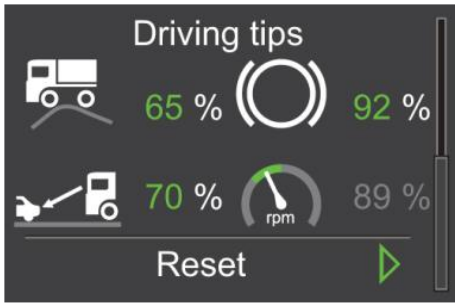
GNSS (GPS)

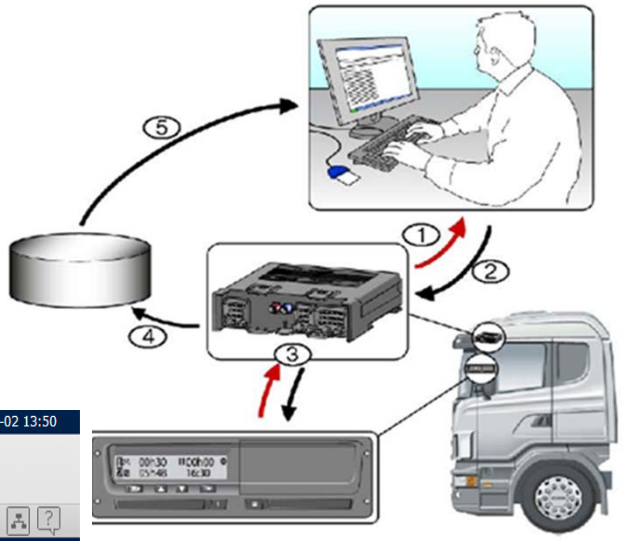
- It is possible to capture data from the vehicle
  - 20/50 Hz data from the engine (load, speed)
  - Vehicle weight – typically used by the gearbox
  - FMS standard is key

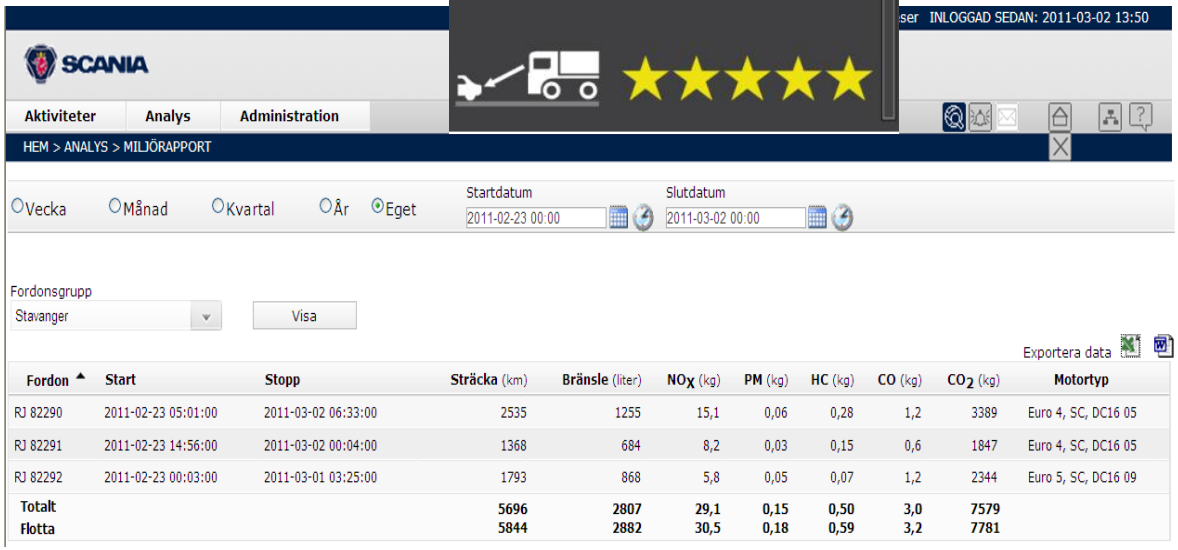
- Global Navigation Satellite Systems
  - Allows for geo-referencing of recorded data, emissions can be fixed to a specific position on the earths surface.
  - Map matching - linking positions to physical features

- Often viewed as waste data
  - Fleet management purposes; where is the truck?
  - Data collected to centralized servers (Volvo, Scania, MAN)
  - Beginning to focus on fuel performance

Manufacturers efforts







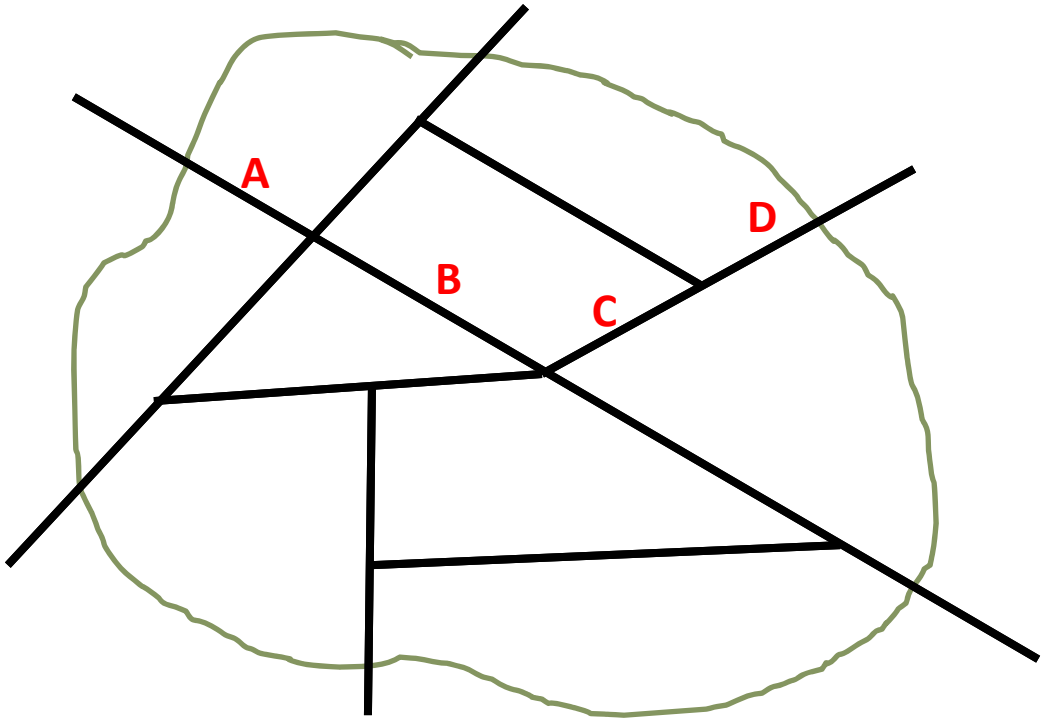
Fordon	Start	Stopp	Sträcka (km)	Bränsle (liter)	NO_X (kg)	PM (kg)	HC (kg)	CO (kg)	CO_2 (kg)	Motortyp
RJ 82290	2011-02-23 05:01:00	2011-03-02 06:33:00	2535	1255	15,1	0,06	0,28	1,2	3389	Euro 4, SC, DC16 05
RJ 82291	2011-02-23 14:56:00	2011-03-02 00:04:00	1368	684	8,2	0,03	0,15	0,6	1847	Euro 4, SC, DC16 05
RJ 82292	2011-02-23 00:03:00	2011-03-01 03:25:00	1793	868	5,8	0,05	0,07	1,2	2344	Euro 5, SC, DC16 09
Totalt			**5696**	**2807**	**29,1**	**0,15**	**0,50**	**3,0**	**7579**	
Flotta			**5844**	**2882**	**30,5**	**0,18**	**0,59**	**3,2**	**7781**	

Some thought from a work in progress

- Working on algorithmic formulations for inducing wanted behaviour.
- Will be iterations with work package 2
- The fight will probably be about details
- This is a world premiere

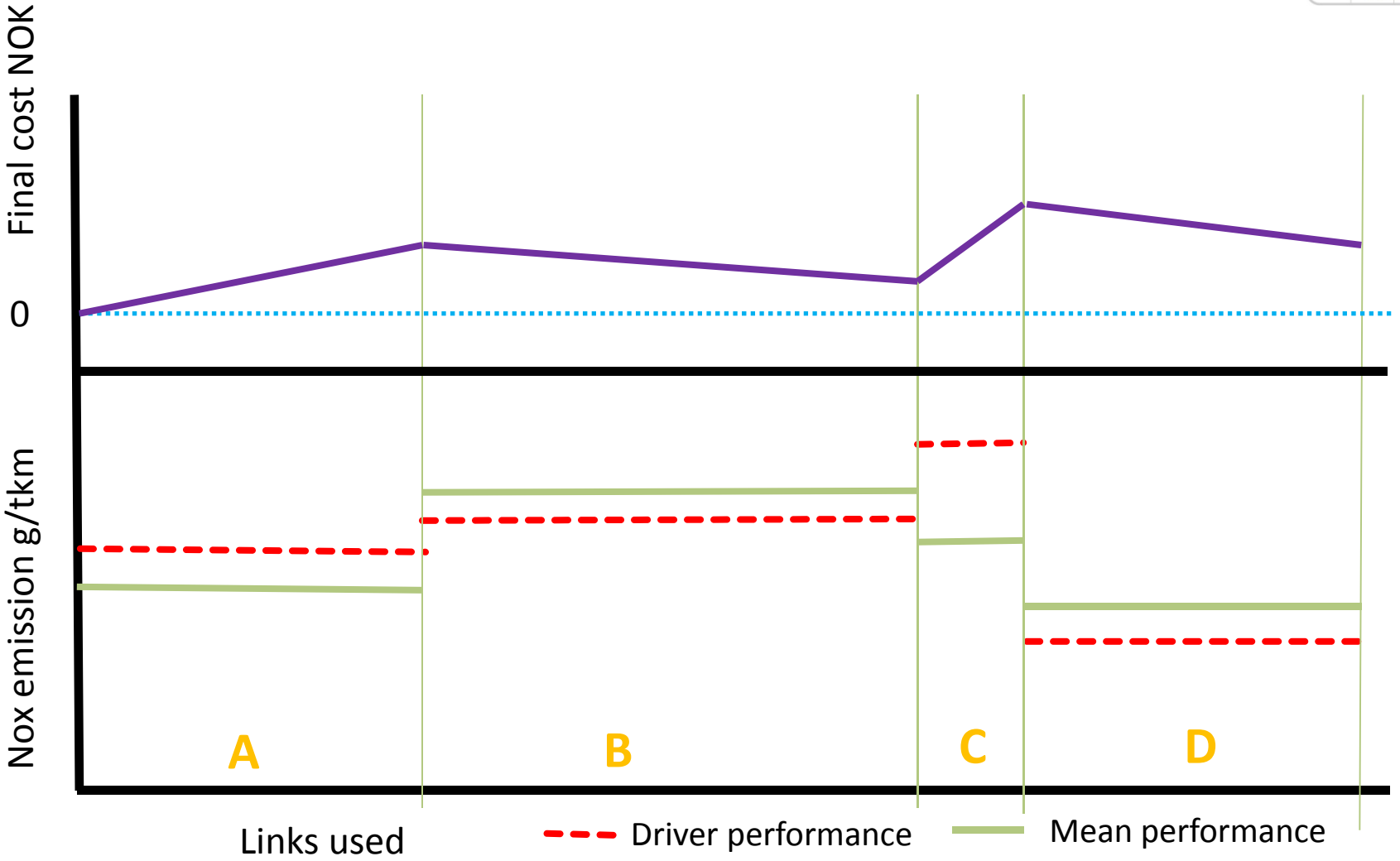
The GAZ application

- Use fiscal measures to induce wanted behaviour



- A set of links inside a cordon
- Compete against the mean g/tkm factors, for vehicle groups
- Hourly means as reference, stored centrally for each link
- Reference link data, mean speed and mean number of stops
- Weighting of links, manage flow. Primarily distance, but also for consolidating flow

A trip within the cordon



Formulation of the GAZ fee

$$GAZ_{Fee} = \sum_{P} \left[\sum_{L} (E_{vehicle} - E_{mean}) \times Cost_{L} \right] \times Cost_{P}$$

- P = Pollutant (CO_2, NO_X,PM,HC,CO)
- L = Link (road segment between two intersections)

- E = Emitted amount in grams/tkm
- An average driver pays nothing

Calculating the "Mean"

- The mean of what ?
  - The mean of a specific traffic situation
  - Factor curves – known from estimation of ADT
    - Theory: traffic flow is the main factor for resulting driving speed
      - Back to the old speed flow curves
    - Hourly
    - Daily
    - Weekly
    - Corrections for holidays and special events

$$\text{Mean} = \frac{Current\ hourly\ mean + Historic\ mean}{2}$$

This formulation picks up extraordinary events, and in the case of traffic growth there will be a pressure to reduce emissions, but not an unrealistic one.

The next stage

- Turning the ideas and algorithms into code
- Collect data from trucks if possible
  - Real emissions could be problematic
  - Collect proxy data and use this to build emission factors (GG)
  - Manufacturer will build what the customers want to pay for
  - The cost of not having the GAZ application – so high that you know it is to high (Same idea as for water meters in Trondheim)
- Alter the design according to discussions with WP 2

- Create a demonstrator for some truck runs in Trondheim.
  - Alternatively run simulations

Thanks for your attention