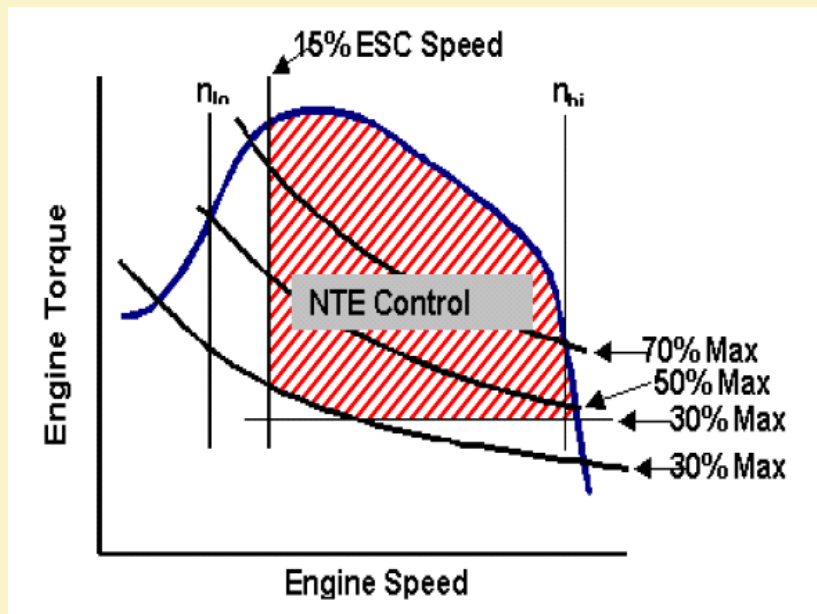


Input for the Discussion about the Development of a NTE Concept.



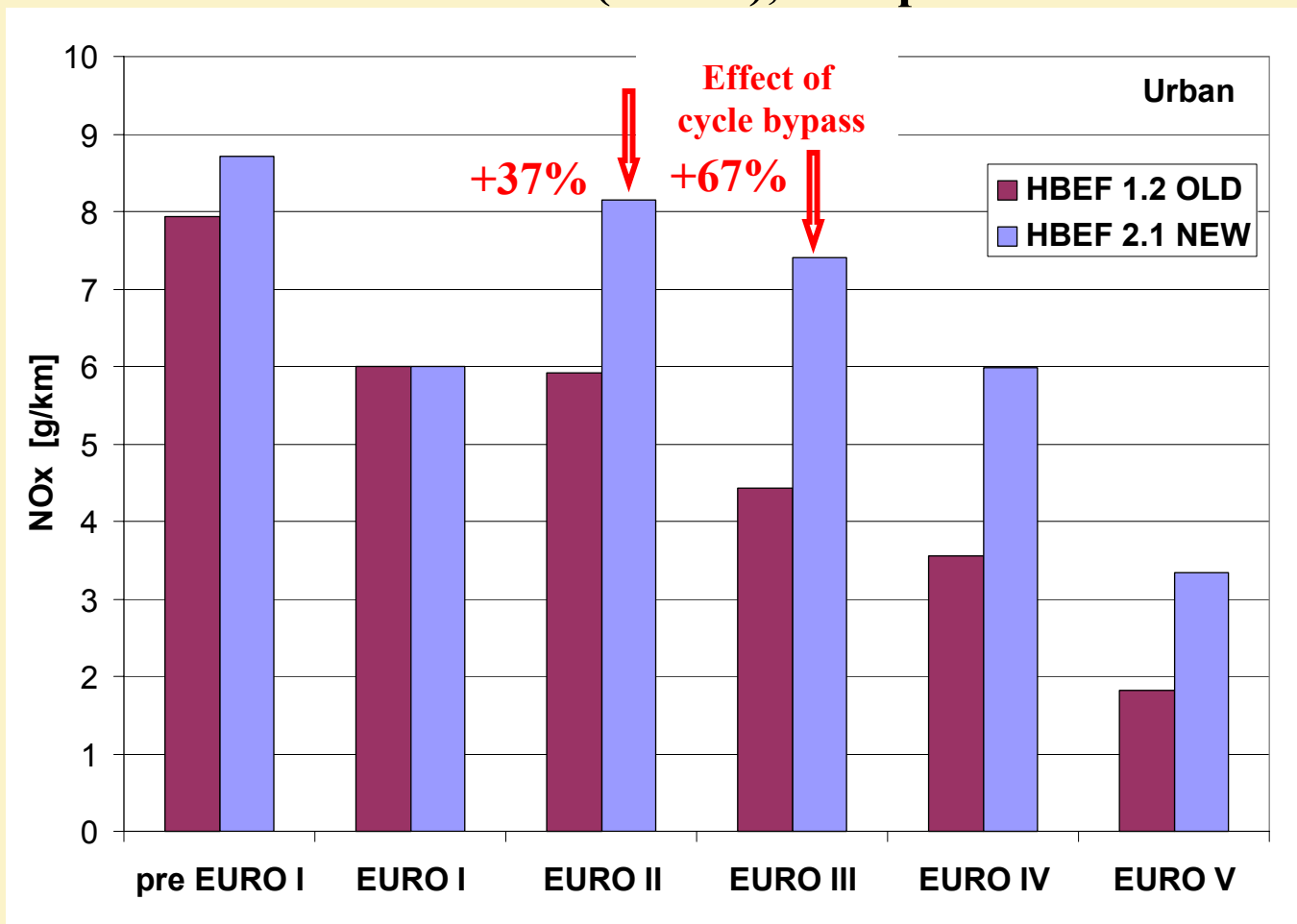
- Starting Point
- Latest HDV Emission Factors
- Comparison of NTE Concepts
- On Road Data
- Questions

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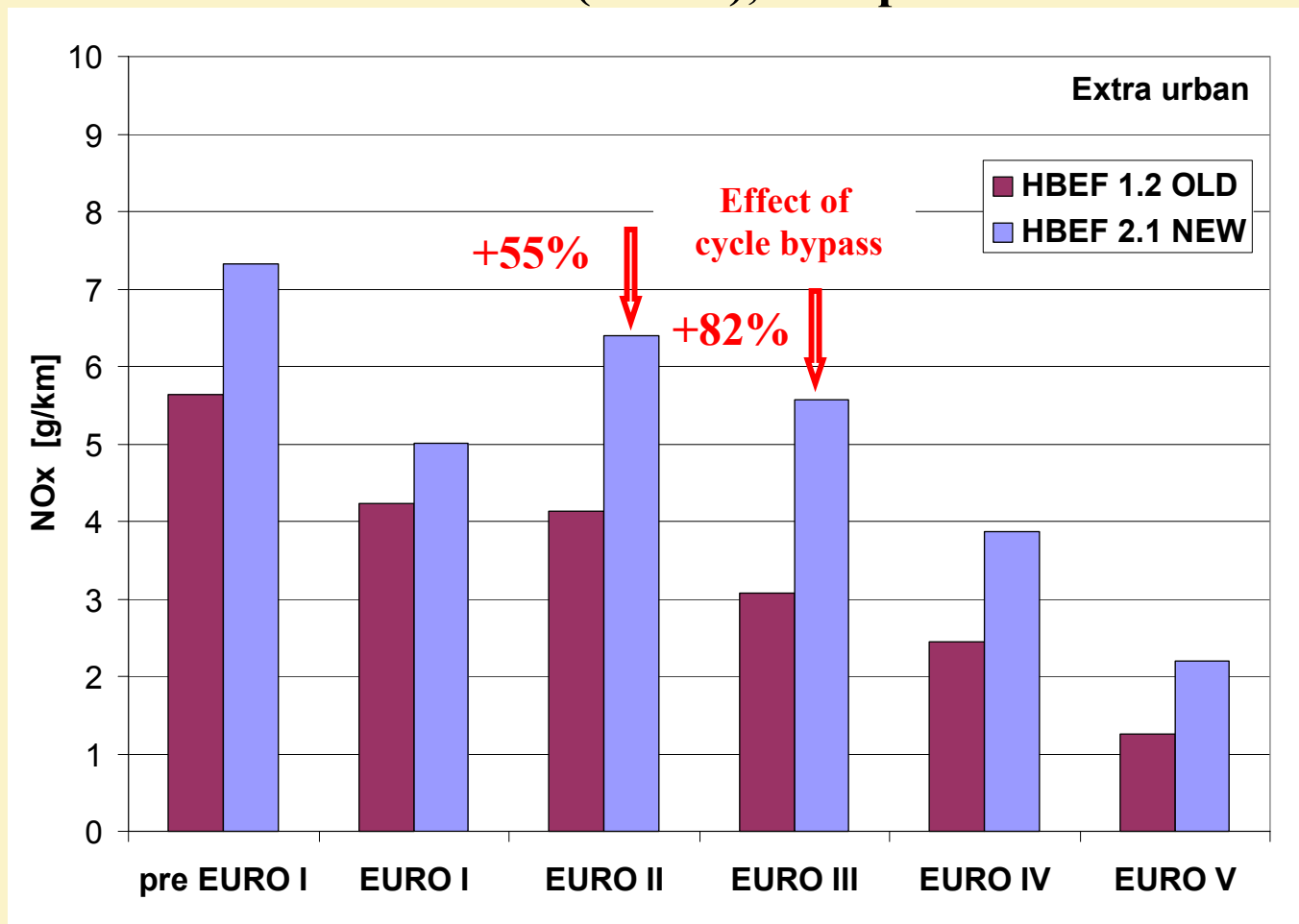
Starting point:

- **Cycle bypass** as well as cycle beating has occurred in HDV in the US and is **still not solved** in Europe (also for passenger cars and motorcycles).
- This off cycle effect leads to a **significant increase of real world NOx emissions** of HDV compared to an emission level corresponding to applicable NOx limits (see new Handbook of Emission Factors for Germany, HBEF 2.1 as of 03/2004).
- **IUC testing on the road** and upcoming **multimap engines** as well as potential chip-tuning mean further arguments for introducing an overall emission ceiling.
- A not to exceed concept (**NTE**) most likely is an **efficient tool** to address this.
- A **NTE** concept for HDV has been developed in the US together with **MAEL** and a **SET (EURO III)** as a consequence of the consent decree to be effective from 2007 on. A **NOx control area** approach is already in force for HDV in Europe from stage EURO III on. A NTE concept in principle, but not yet defined in all details, will also be introduced for off road machinery in Europe from 2011 on.
- What is the **appropriate basis** for the further discussion of a world harmonized NTE concept in the OCE working group?

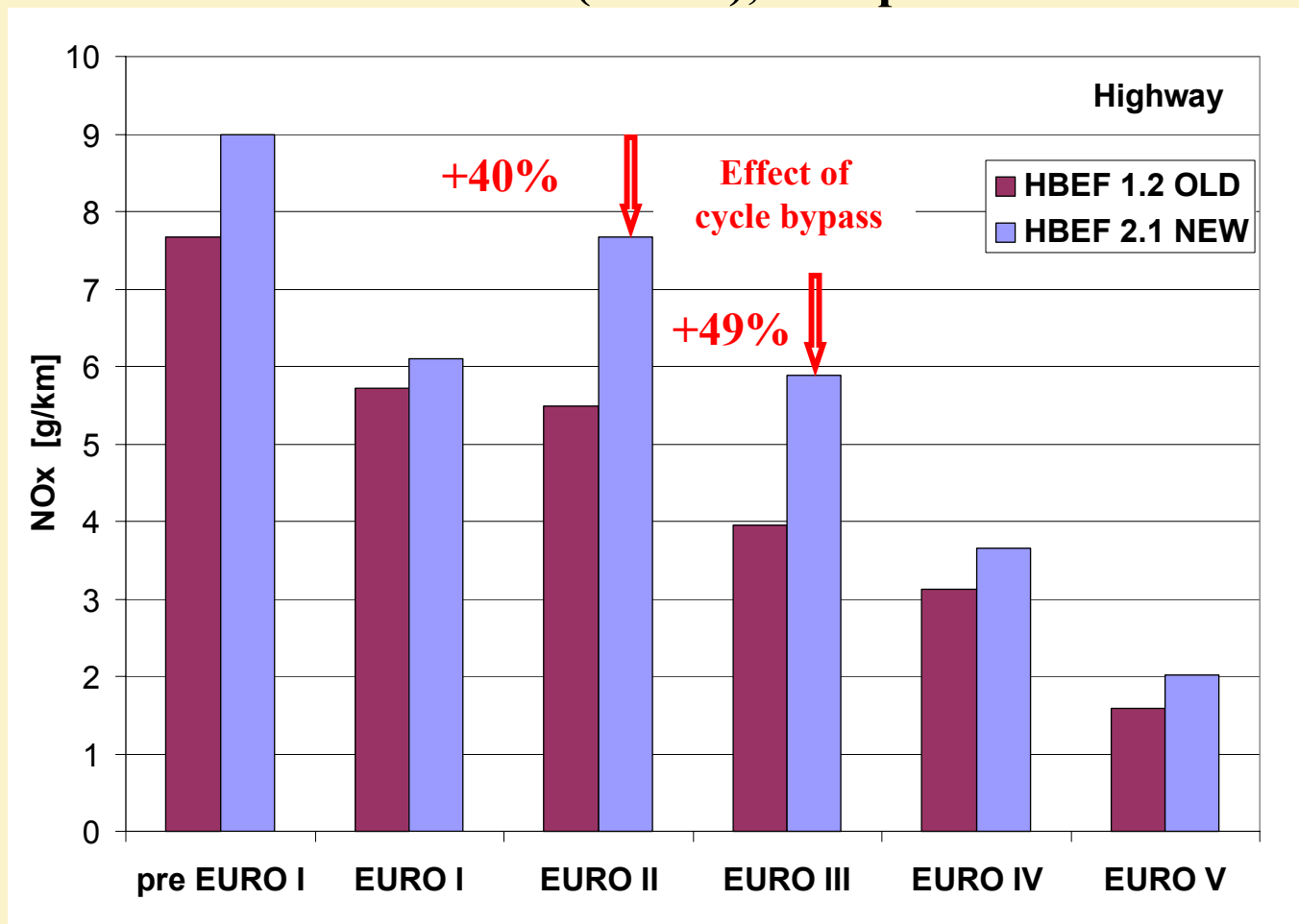
Average NO_x Emission Factors of HDV in Germany: Handbook of Emission Factors (HBEF), Comparison NEW versus OLD



Average NO_x Emission Factors of HDV in Germany: Handbook of Emission Factors (HBEF), Comparison NEW versus OLD

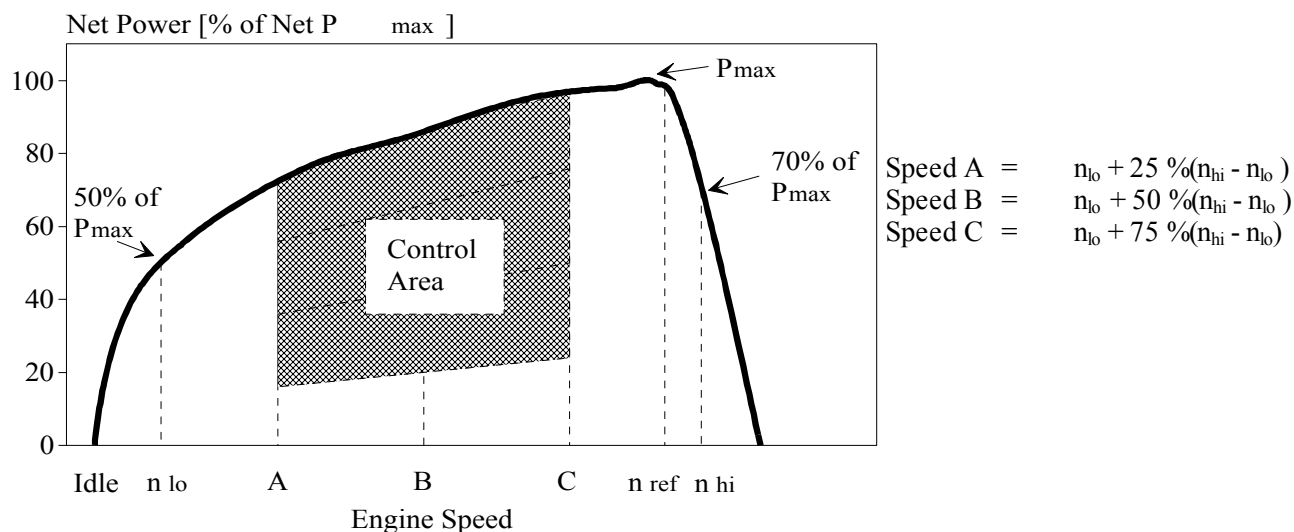


Average NO_x Emission Factors of HDV in Germany: Handbook of Emission Factors (HBEF), Comparison NEW versus OLD



CYCLE BYPASS PREVENTION

ELEMENTS OF THE EU PROCEDURE – NO_x CONTROL PROCEDURE

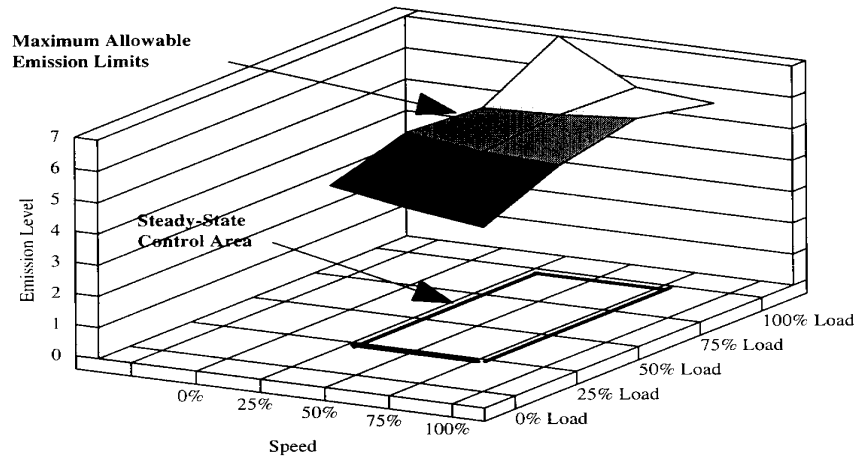


- Control area based on current EU driving patterns
- NO_x emission at the individual test modes can be adjusted according to the weighting factors to meet the limit over the test cycle
- Measured NO_x emission at any point within the control area must not exceed by more than 10 % the corresponding values interpolated from the adjacent test modes as measured during the test run

WHDC SG/FE 28/02/2000

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Source: EPA, WHDC SG/FE Meeting, Brussels, 28/02/2000

CYCLE BYPASS PREVENTION ELEMENTS OF THE USA PROCEDURE - MAEL



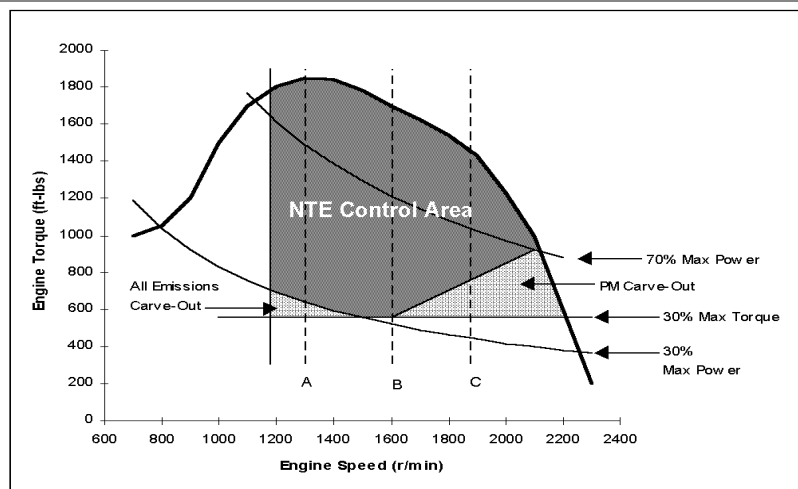
- Emissions "surface" map established within the ESC control area from the 12 non-idle modes
- MAELs apply to each point on this "surface" during all operations including transient
- MAELs apply to certification, production line and in-use engines
- MAELs apply under the expanded ambient conditions including altitude

WHDC SG/FE 28/02/2000

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CYCLE BYPASS PREVENTION

ELEMENTS OF THE USA PROCEDURE - NTE CONCEPT



- Definition of a new control area (the "NTE" zone) that is broader than the ESC control area
- Definition of specific emissions carve-out zones under low load operation
- Each regulated emission must not exceed 1.25 times the FTP standard within the NTE zone
- NTE standards apply under any conditions of normal vehicle operation including steady state and transient and expanded ambient conditions

WHDC SG/FE 28/02/2000

15

Source: EPA, WHDC SG/FE Meeting, Brussels, 28/02/2000

European Council 2002/0304 (COD) amending 97/68/EC, October 10, 2003 (non road mobile machinery, including vessels, locomotives and railcars)

Considerations

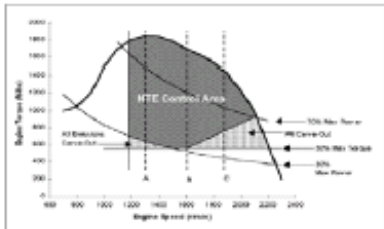
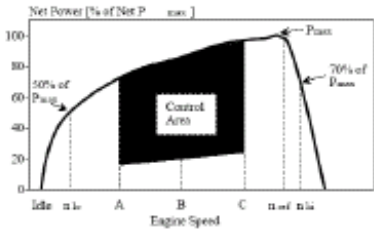
6. Under randomly selected load conditions and within a defined operating range, the limit values shall not be exceeded by an appropriate percentage.
7. Moreover, the use of defeat devices and irrational emission control strategies must be prevented

Annex 1

4.1.2.7 In the case of emission standards contained in sections 4.1.2.5 and 4.1.2.6, under all randomly selected load conditions, belonging to a **definite control area** and with exception of specified engine operation conditions which are not subjected to such a provision, the emissions sampled during a time duration as small as 30 s shall **not exceed by more than 100% the limit values** of the above tables*. The control area to which the not to exceed percentage shall apply and the excluded engine operation conditions will be defined according to the procedures laid down in the article 15.

* tables: type approval limits

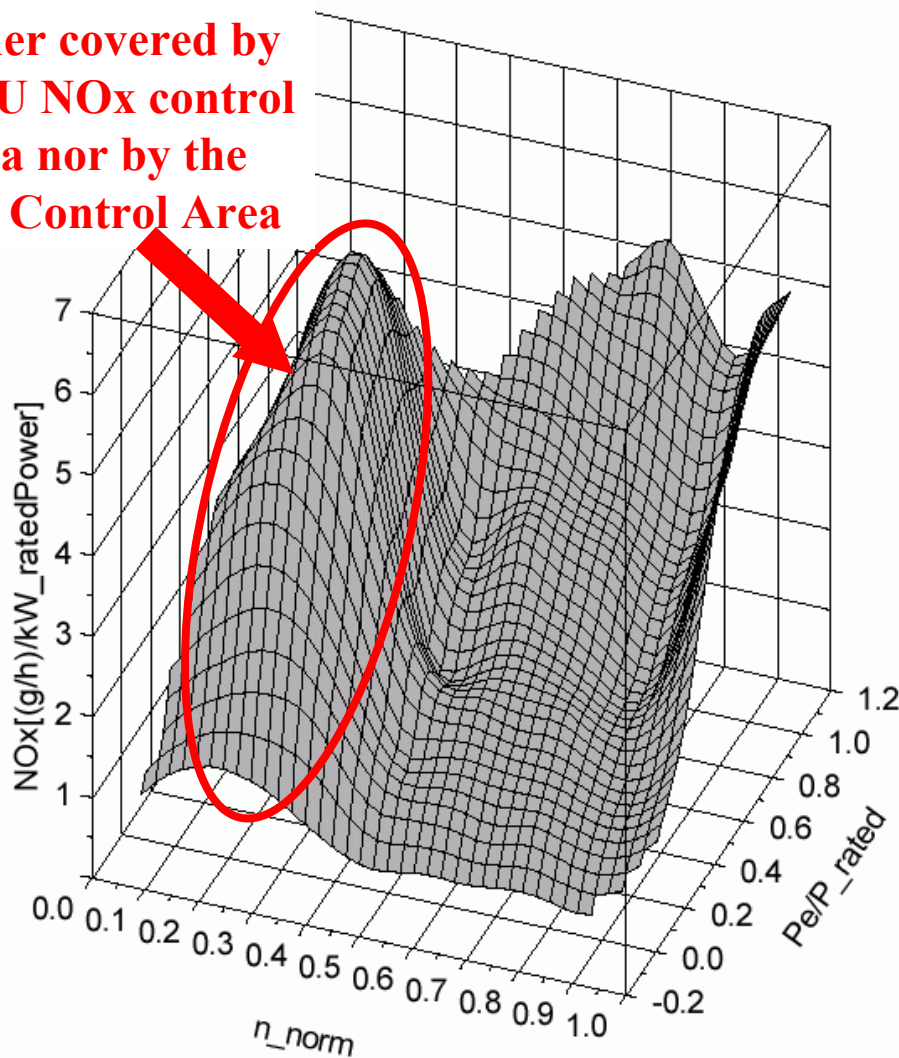
Comparison of Existing NTE/MAEL Concepts (1)

Regulation	40 CFR – Chapter I - § 86.1370-2007 and other §§	European Directive 99/96/EU (CFR § 86.1360 – 2007 MAEL is similar)	European Council 2002/0304 (COD) amending 97/68/EC, October 10, 2003
Application from [year]	2007	EU: 2000 (EURO III) US: 2007, eliminated with phase 2 in 2010	2011 (stage III B)
Scope of engines	On road HDV diesel engines	On road HDV diesel engines	Non-road mobile diesel machinery, including locomotives, railcars and inland vessels
Emissions considered	CO, NMHC, NO _x , PM, Smoke	EU: NO _x MAEL: gaseous pollutants	CO, HC, NO _x , PM
Operating conditions	All randomly selected modes	3 randomly selected stationary modes (US: transient possible, but not applied)	All randomly selected modes
Ambient conditions	Specified ambient conditions and ambient corrections	Standard laboratory ambient conditions	Standard ambient conditions
Control area, operating range	NTE control area (broader than ESC control area) 	ESC control area 	Definite control area (to be determined)

Comparison of Existing NTE/MAEL Concepts (2)

Regulation	40 CFR – Chapter I - § 86.1370-2007 and other §§	European Directive 99/96/EU (CFR § 86.1360 – 2007 MAEL is similar)	European Council 2002/0304 (COD) amending 97/68/EC, October 10, 2003
Carve outs	At low speeds and below 30% of max. power, PM carve out deleted	None	None, so far
Special consideration of aftertreatment systems	Warm up, averaging period must include regeneration events,	Operating conditions to be representative, regeneration events to be included	None, so far
Duration of selected modes	Minimum 30 s, but may be much longer with regenerating aftertreatment systems	As ESC test modes (120 s)	30 s
NTE limit values	1,25 times the applicable FTP limit value, 1,50 x with phase 2 standards in 2010 also in use,	+ 10% of the corresponding value interpolated from the 4 adjacent ESC test modes	+ 100% of applicable limit values
Specified exceptions on petition of the manufacturer	Several exceptions possible to exclude operating points, deficiency provisions until 2013	none	“Exception of specified engine operation conditions not subject to such a provision” (to be determined)

**neither covered by
the EU NO_x control
area nor by the
NTE Control Area**

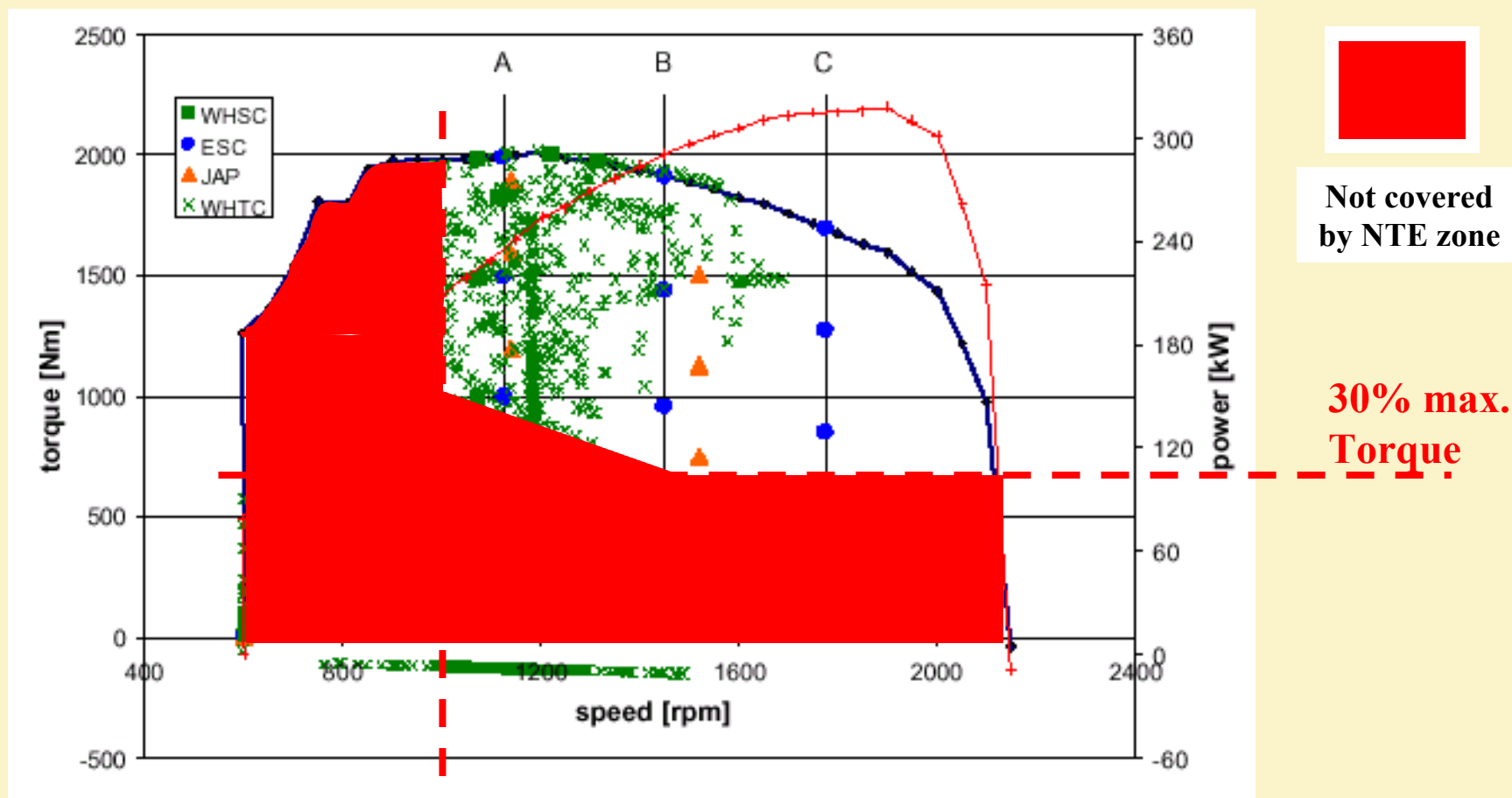


Normalized NO_x map of a EURO III HDV engine

**Sharp increase of NO_x
emissions outside the
control area at low
speeds.**

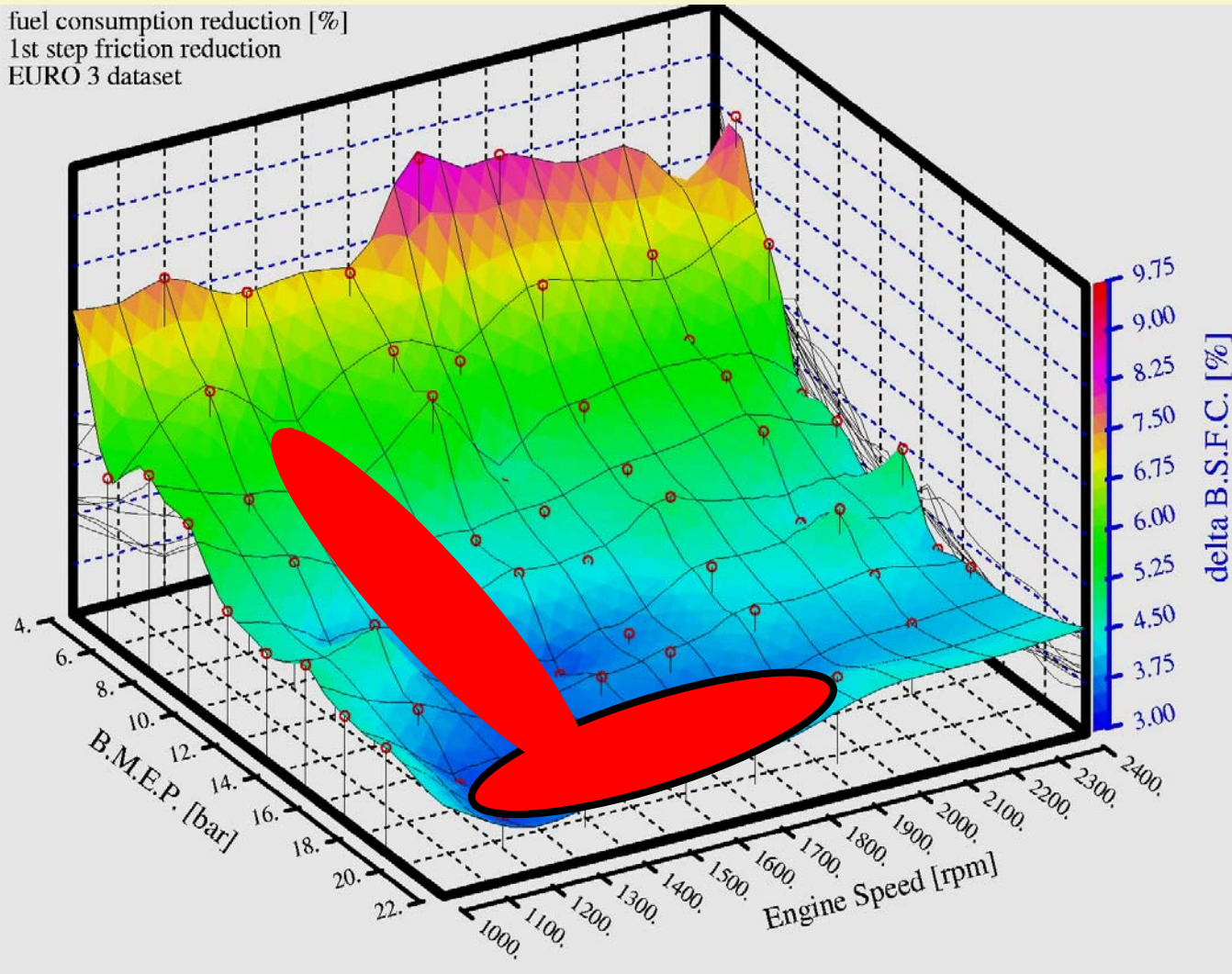
Quelle: Hausberger et al.

Characteristics and Test Cycle Measuring Points of a HDV Engine



Source: EMPA, 01/2002

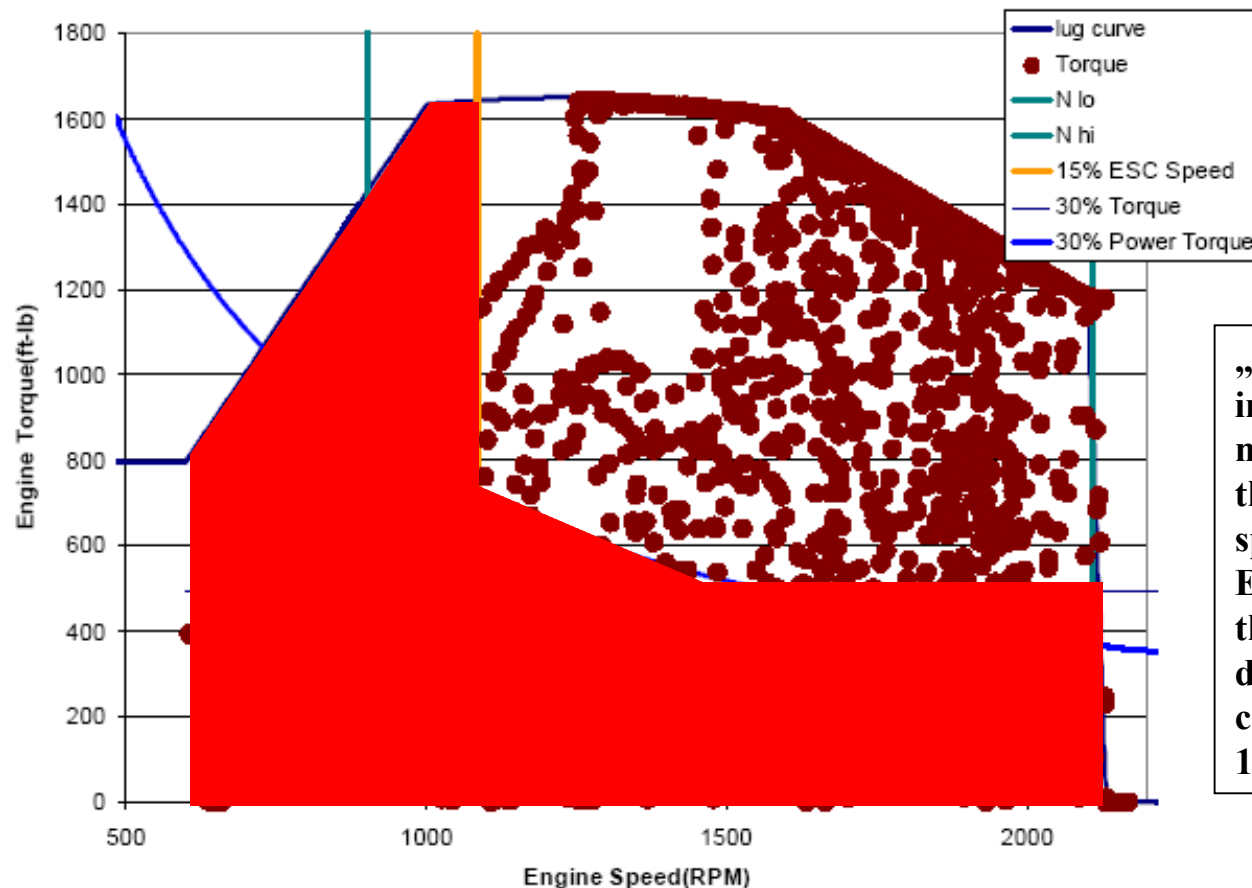
fuel consumption reduction [%]
1st step friction reduction
EURO 3 dataset



95% of actual driving of a 40 t truck (EURO III) takes place in the area marked in red. (IVECO)

Source: IVECO 2003

Engine Operation Over an On-road Route

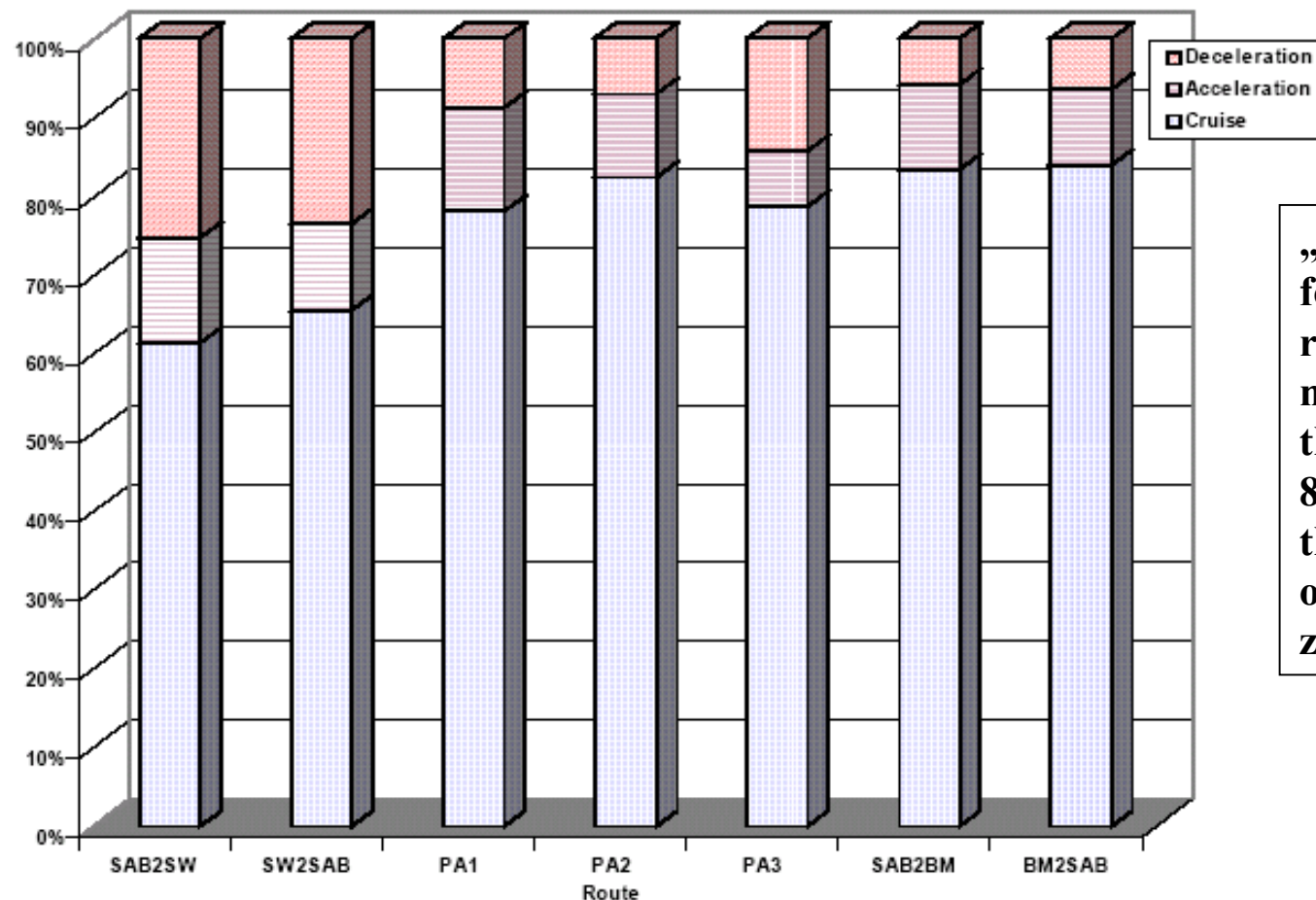


Not covered
by NTE zone

„A modal analysis indicated that the cruise mode comprised 70% of the time that the vehicle spent in the Not-to-Exceed (NTE) zone while the acceleration and deceleration modes covered about 20% and 10% respectively“

Source: Mridul Gautam (West Virginia University), DEER 2003

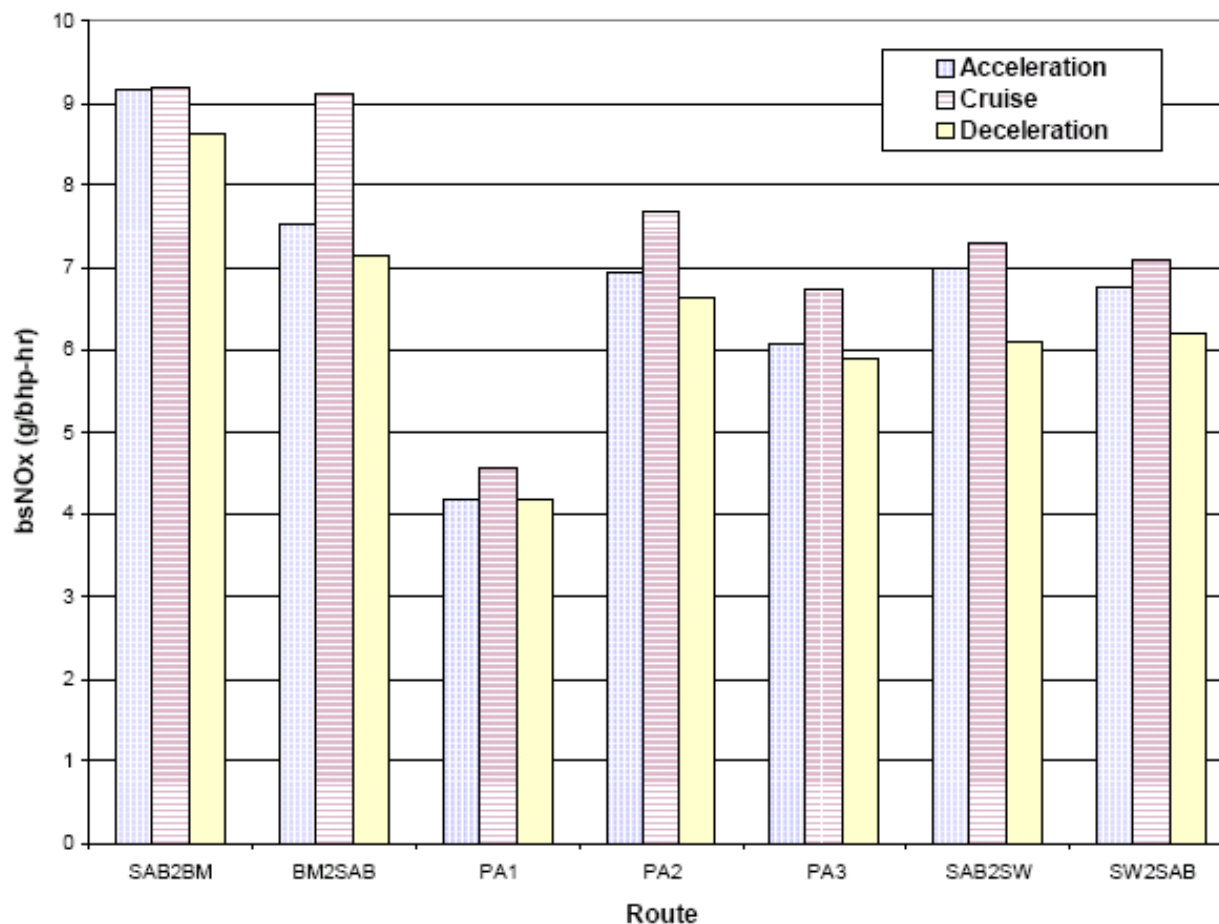
Distribution of acceleration, cruise and deceleration modes with respect to time spent in the NTE zone with several HDV on different routes



„It can be seen that for all of the test routes, the cruise mode accounts for the majority (60 – 80%) of the time that the engine operated in the NTE zone.“

Source: Krishnamurthy, WVU 2003

Average modal emission rate of NO_x on different routes for Engine A

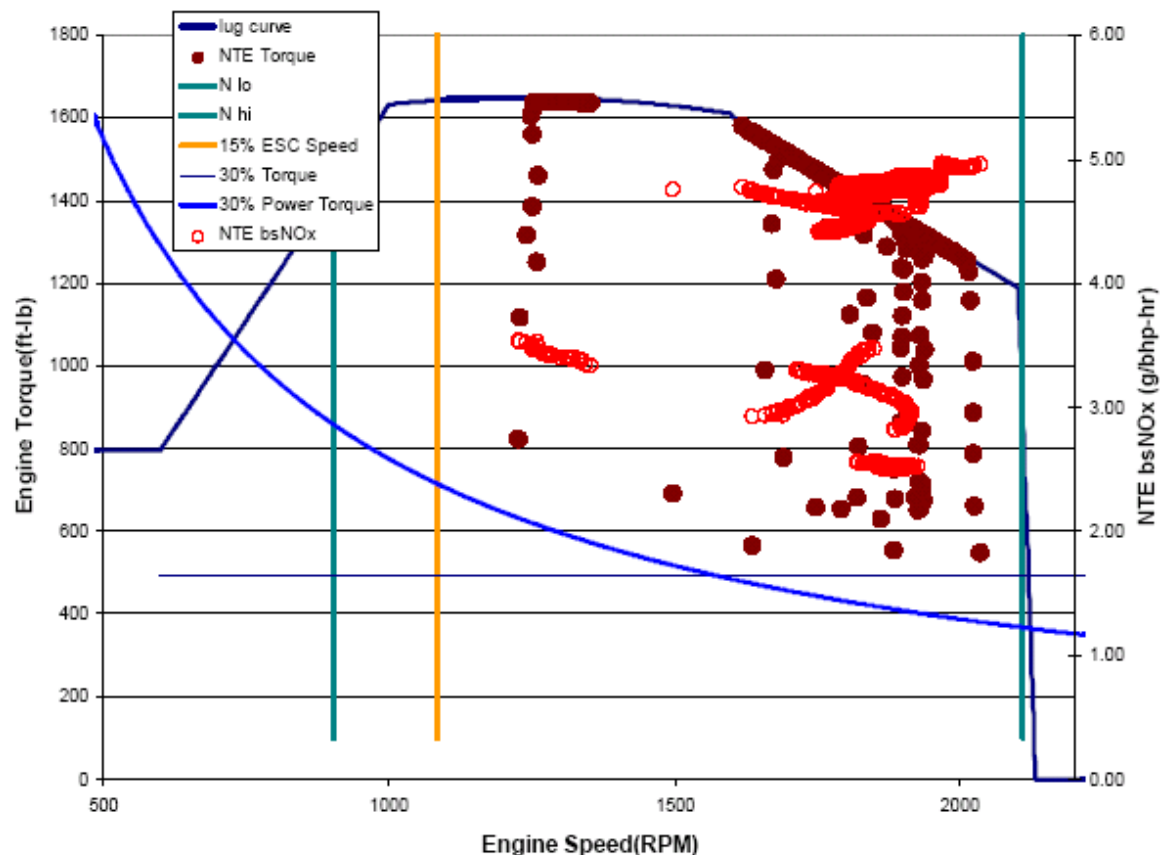


„The mean emission rates for NO_x were the highest for cruise mode.

The acceleration mode produces slightly lesser amount of NO_x emissions compared to the cruise mode and deceleration mode produces the least amount of NO_x emissions.“

Source: Krishnamurthy, WVU 2003

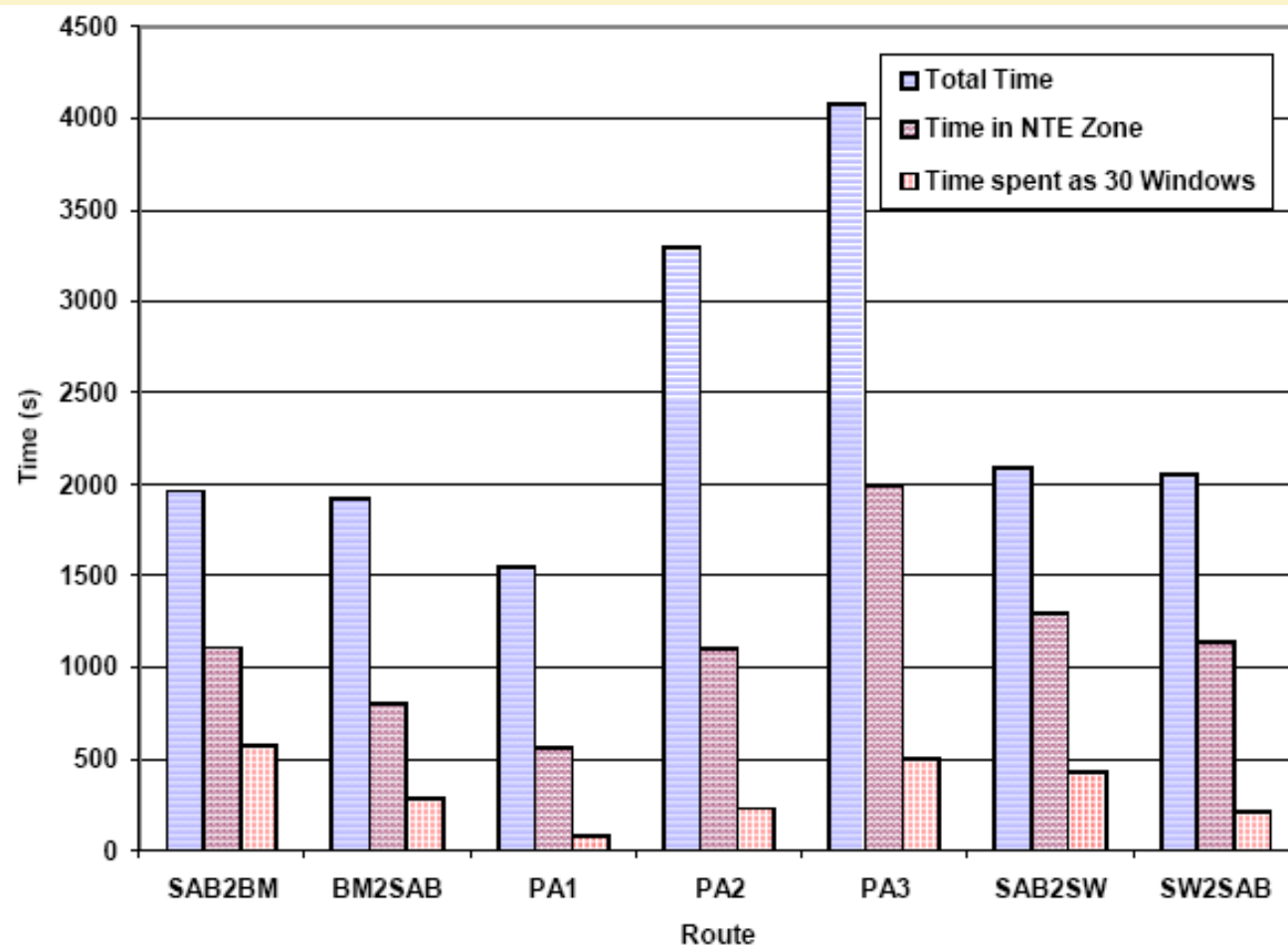
NTE Zone: Engine Operation and Brake Specific NO_x as a function of Engine Speed and Engine Load



“The majority of the engine operation over 30s windows within the NTE zone occurred along the full load curve (example of one route, on road measurements).“

Source: Mridul Gautam (West Virginia University), DEER 2003

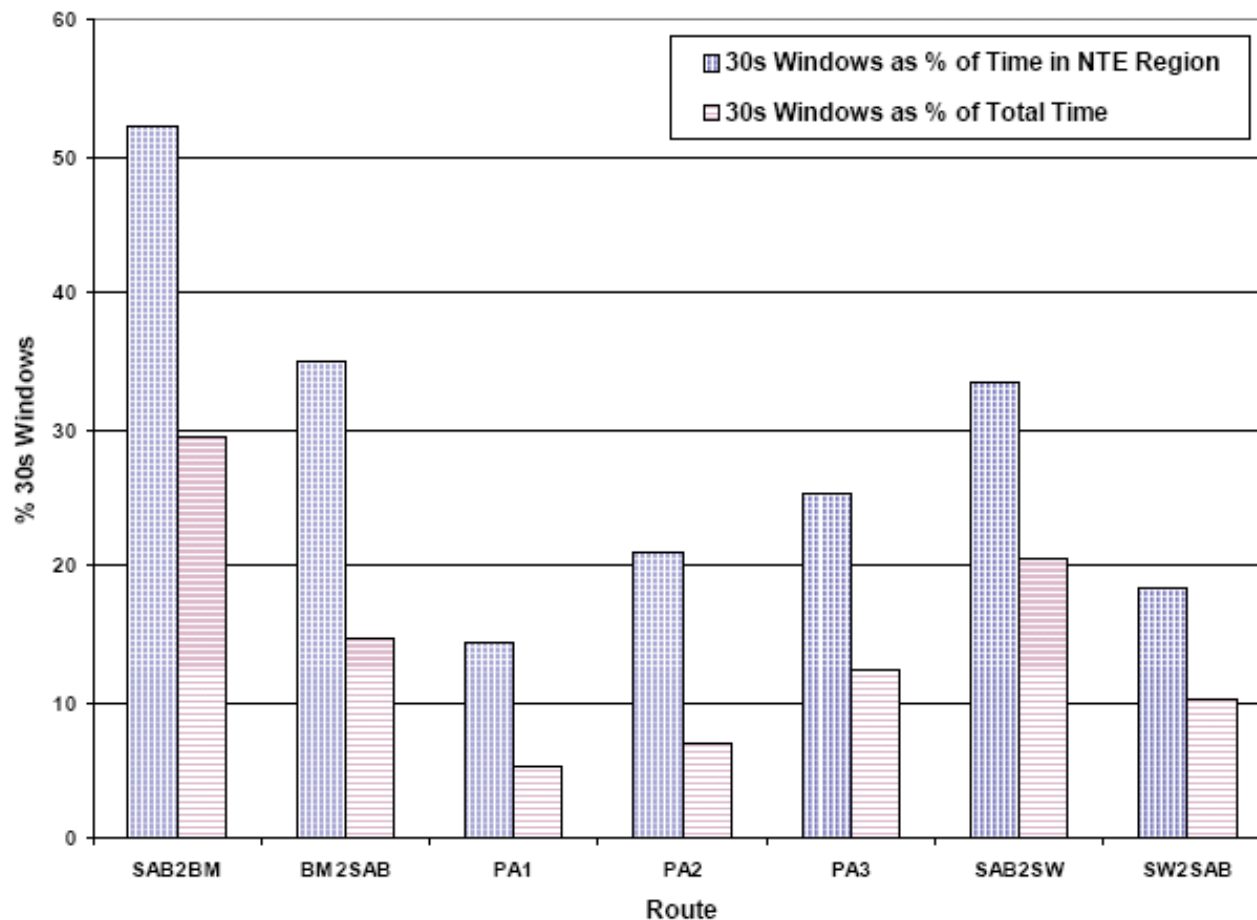
Comparison of time in NTE zone and 30s windows with several HDV on different routes



Only a small
timeshare is
spent in 30s
windows within
the NTE zone

Source: Krishnamurthy, WVU 2003

Comparison of percentage of 30s windows in NTE zone and total time with several HDV on different routes



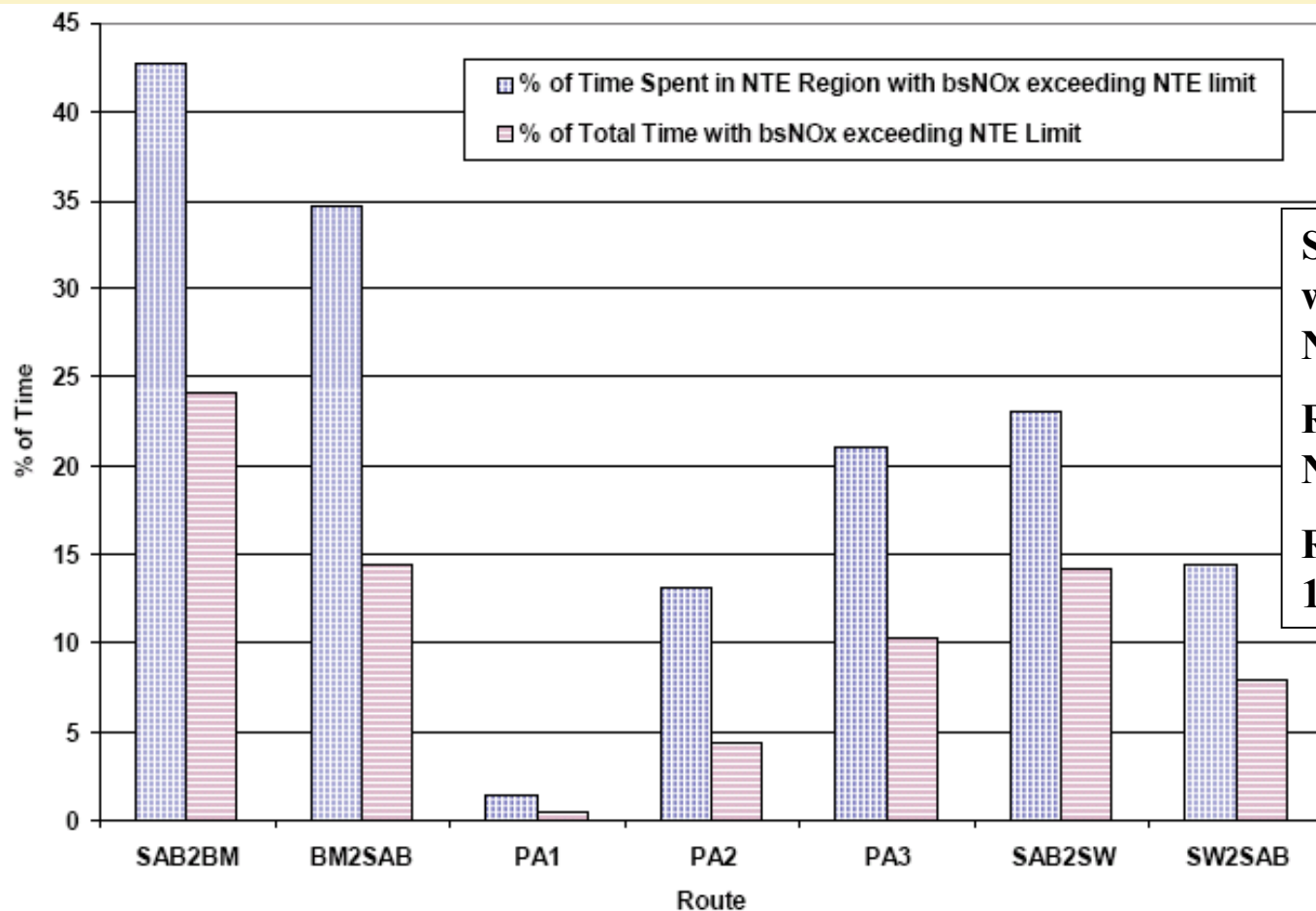
Share of 30s windows:

**Related to time in
NTE zone:
15 – 52%**

**Related to total time:
5 – 30%**

Source: Krishnamurthy, WVU 2003

Comparison of percentage of 30s windows with bsNO_x exceeding NTE limit (in NTE zone and total time) for several HDV on different routes

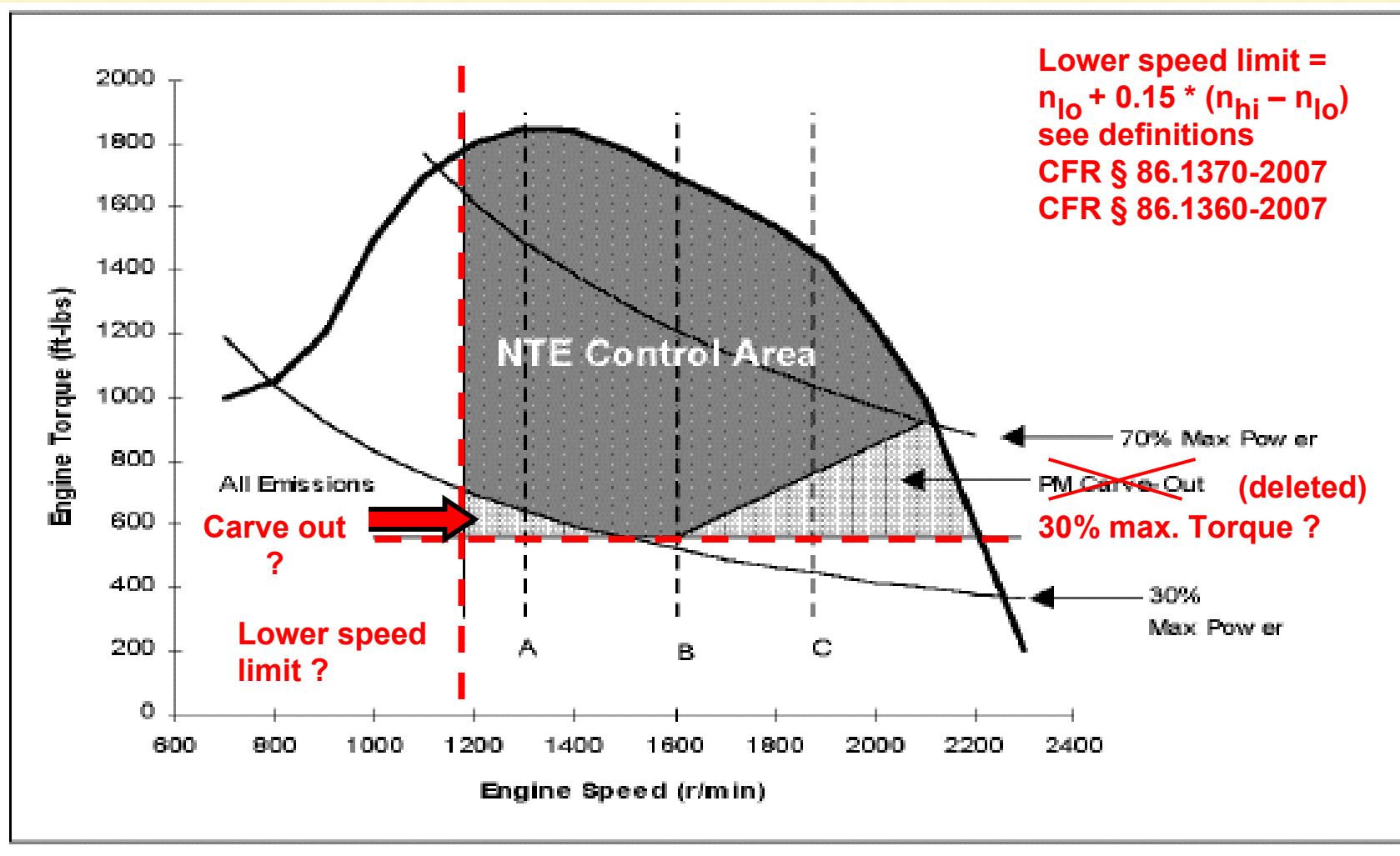


**Share of 30s windows
with NO_x exceeding
NTE limit:**

**Related to time in
NTE zone: 2 – 43%**

**Related to total time:
1 – 24%**

Source: Krishnamurthy, WVU 2003



Questions (1):

- Is the NTE/MAEL 2007 concept of the US the best to start with ? If YES.....
- What was the rational of EPA to design the NTE/MAEL concept this way ?
- What is the experience of EPA with the voluntary application (type approval/ in use) in advance of the 2007 requirements ?
- Is it necessary to have a NTE requirement as well as a MAEL requirement in parallel ?
- Are there reasons to limit a NTE and/or MAEL control area to certain speed and torque values ?
If YES, is this dependant on certain technologies or engine layout ?
- In use data of HDV indicates that a relevant proportion of driving events occurs outside the US NTE 2007 control area. What does it mean in terms of emissions (NO_x and PM) of future engines ?
Are emission maps of modern/future engines available or predictable ?
Are driving frequency maps of modern/future engines available or predictable?

Questions (2):

- If a NTE control area is defined, is there a need for technology specific or emission specific carve outs ?
- Have the 30s windows proven to be appropriate ?
- In the US 2007 regulations several specific exceptions of operating modes are possible on petition of the manufacturer. What is the rational, are they really necessary ?
- Definition of NTE/MAEL limit level may be discussed later, but has an interrelation with the definition of the control area and other boundary conditions.

Thank you for your attention !