HIGH EMISSION RISKS DESPITE HIGHLY EFFICIENT EMISSION CONTROL

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TNO innovation for life

TODAY

1. Introduction.
2. ***Risks*** & stakeholders.
3. ***Risk*** investigation, facts and figures.
4. Vehicle technologies & emissions.
5. Two contributions for reduction of ***risks*.**

Mission: Our noble task is to reduce (vehicle) emissions which may contribute to a better air quality and a less negative health impact.

MISSION OF TNO

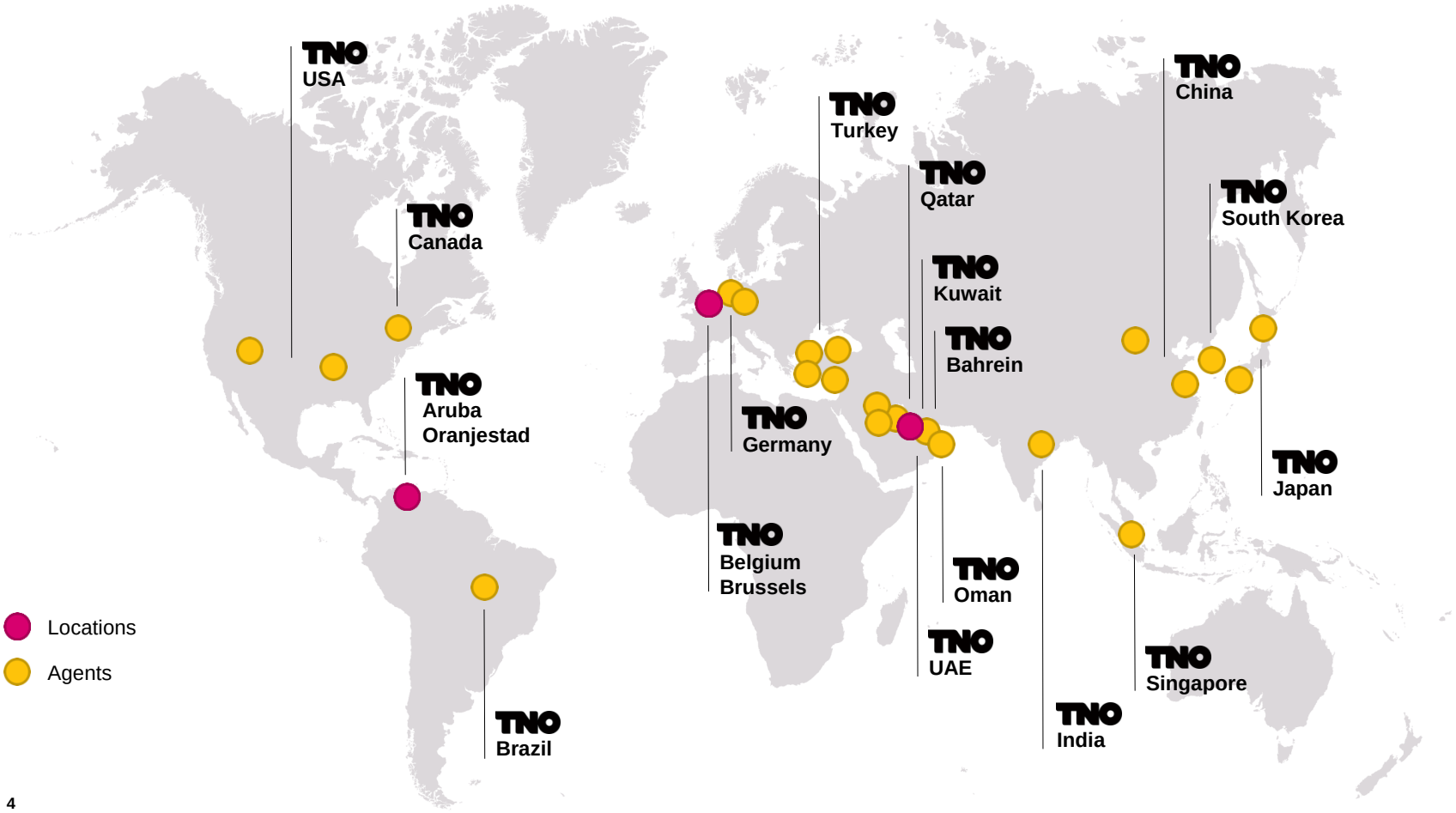
TNO connects people and knowledge to create innovations that boost the sustainable competitive strength of industry and well-being of society.

'INNOVATION FOR LIFE'

TNO is an independent Dutch multidisciplinary research organization for applied research (no shareholders), defined in the Dutch TNO law.

3000 employees.

INTERNATIONAL LOCATIONS / AGENTS



REAL WORLD EMISSION RESEARCH

1968 - 2017

L’ histoire se répète.

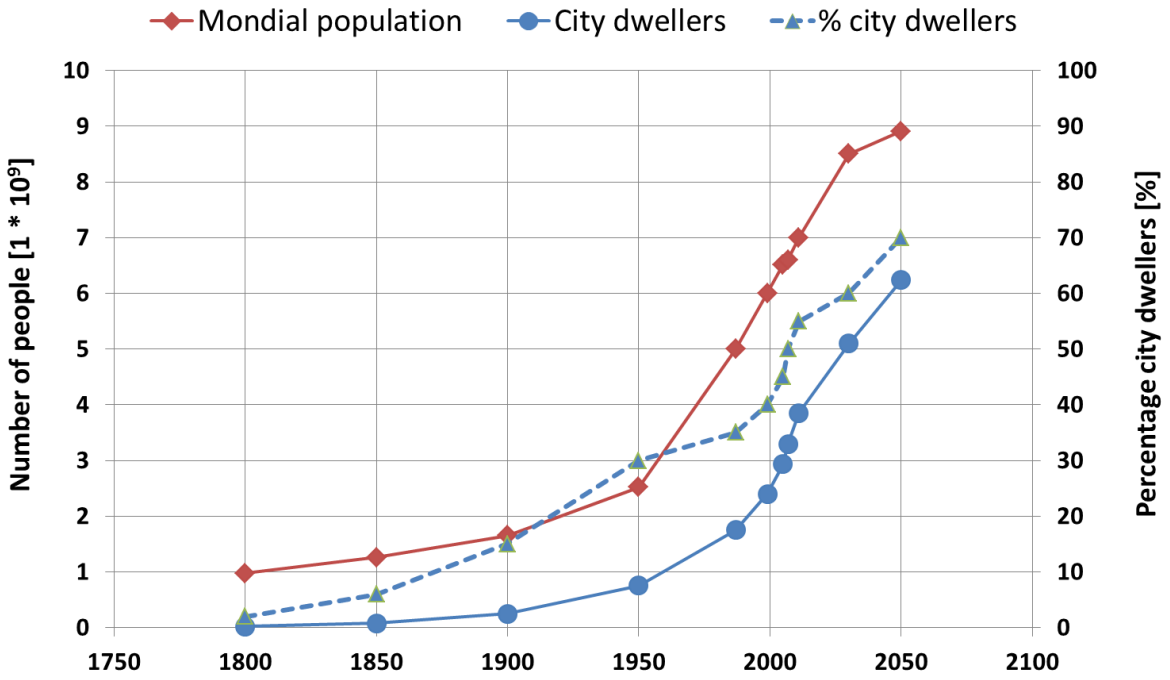
OBVIOUS RELATIONSHIP OF SAFETY RISK & HEALTH

Risk is the potential of losing something of **value**.

This risk is accepted by many stakeholders because the direct health effects are very obvious.

We are willing to pay and to act in order to have more private safety in ***traffic***.

URBAN POPULATIONS & PROSPERITY & DRAWBACK



Contributors to grow of urban populations:

- Industrialisation
- Infrastructure
- Mobility

Last 50 years urban populations tripled.
Air pollution is an assassin because it is related to *economic activities*.

AIR QUALITY OF URBAN AREAS ON A WIDER SCALE

Sources of air pollution:

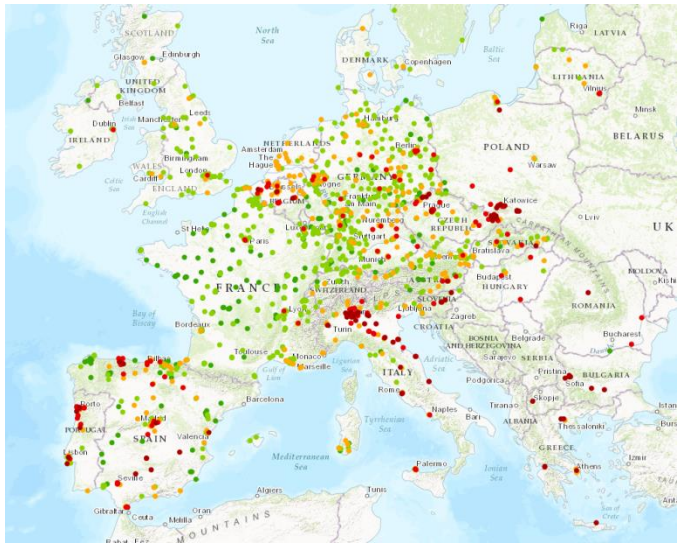
- *Industrial activities*
- *Traffic*
- *Households*
- *Agriculture*

Value: Our health & quality of life

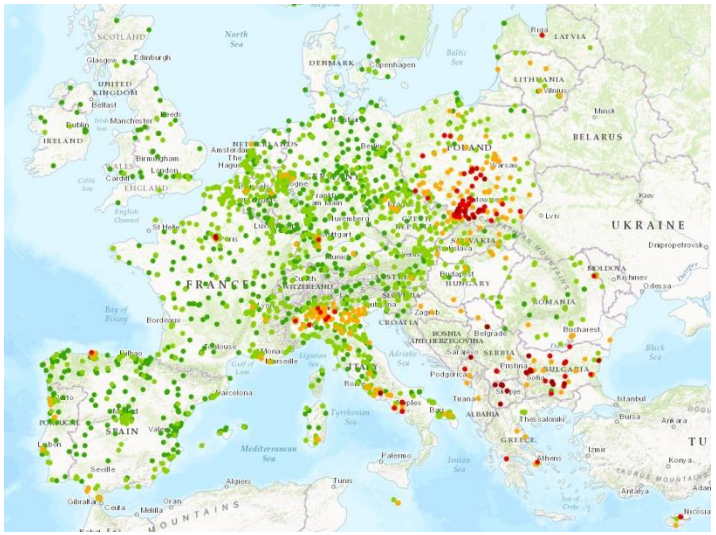
EC 2008/50/EG	Annual basis	Daily basis	Maximum daily 8 hour mean	Permitted exceedances per year
	[µg/m^3]	[µg/m^3]	[mg/m^3]	[day]
NO_2	40	200	-	18
PM10	40	50	-	35
PM2.5	25	-	-	-
CO	-	-	10	-

Economic prosperity starts innocent but the sting is in the tail.
Traffic is one of the contributors.

PM10 2003 AND 2013



2003

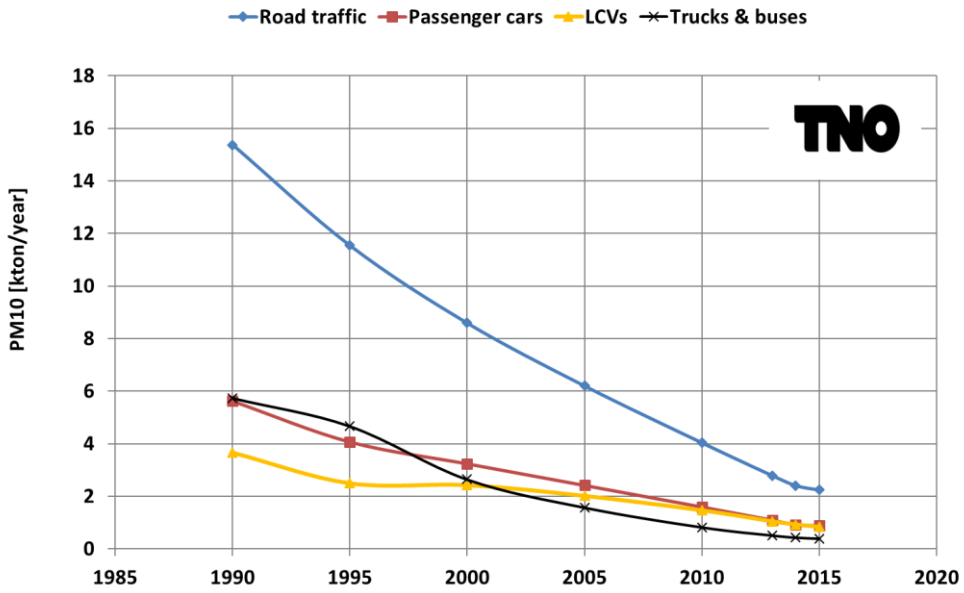


2013

Although the total vehicle mileage between 2003 and 2013 slightly increased, air quality in many regions improved substantially. Certain areas and cities still have a way to go.

http://www.eea.europa.eu/themes/air/interactive/pm10

PM10 EMISSIONS OF DUTCH ROAD TRAFFIC

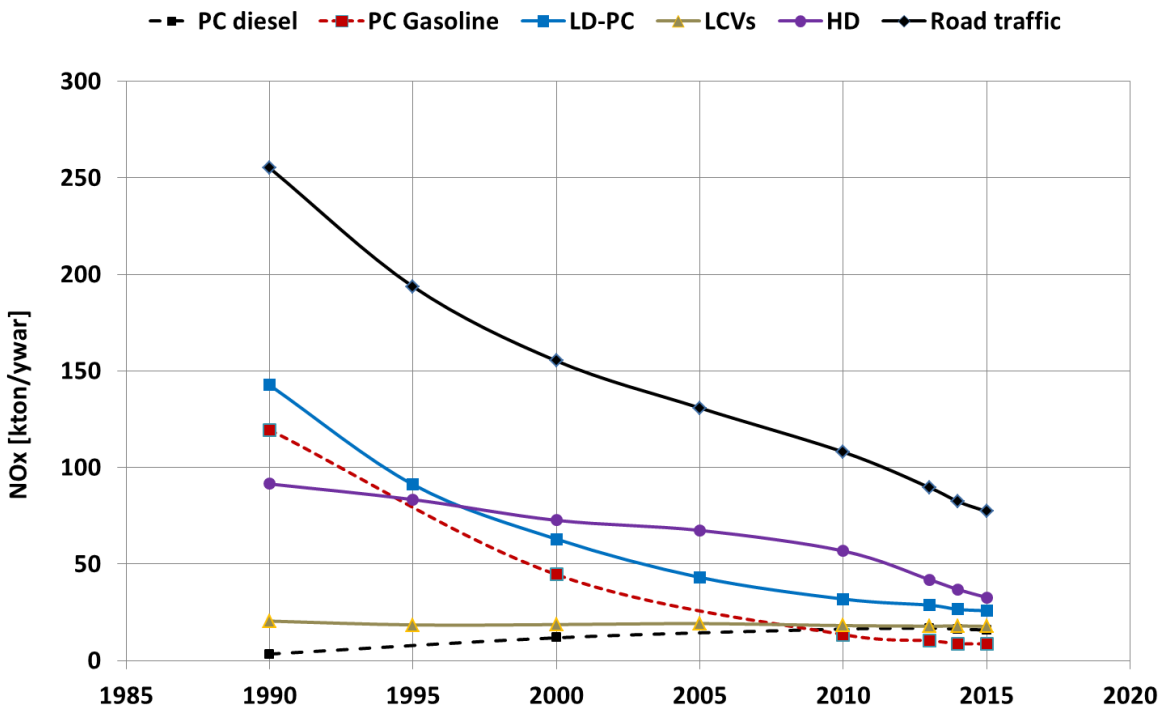


Passenger car fleet:
15% diesel
85% gasoline

Applied **fuel injection technologies** cause a decrease of PM10 emissions. **Diesel Particulate Filters** will contribute to a further decrease. Source: CBS

What is the emission performance of older vehicles which are exported? DPF REMOVAL and/or manipulation is a risk because engine technologies deteriorate.

NOX EMISSIONS OF DUTCH ROAD TRAFFIC



Passenger car fleet:
15% diesel
85% gasoline

NOx: HD and LD-gasoline decrease, **LD-diesel and LCVs increase.**

Applied ***technologies & controls*** have a major impact on emissions.

Source: CBS

DIESELGATE ⟷ **EGR and/or SCR manipulation!**

INVESTIGATION OF EMISSION RISKS

- Assumption:

Real world emission ***risks*** are related to societal systems & stakeholders.

Impact = Risk * Probability

WHO IS RESPONSIBLE FOR EMISSIONS?

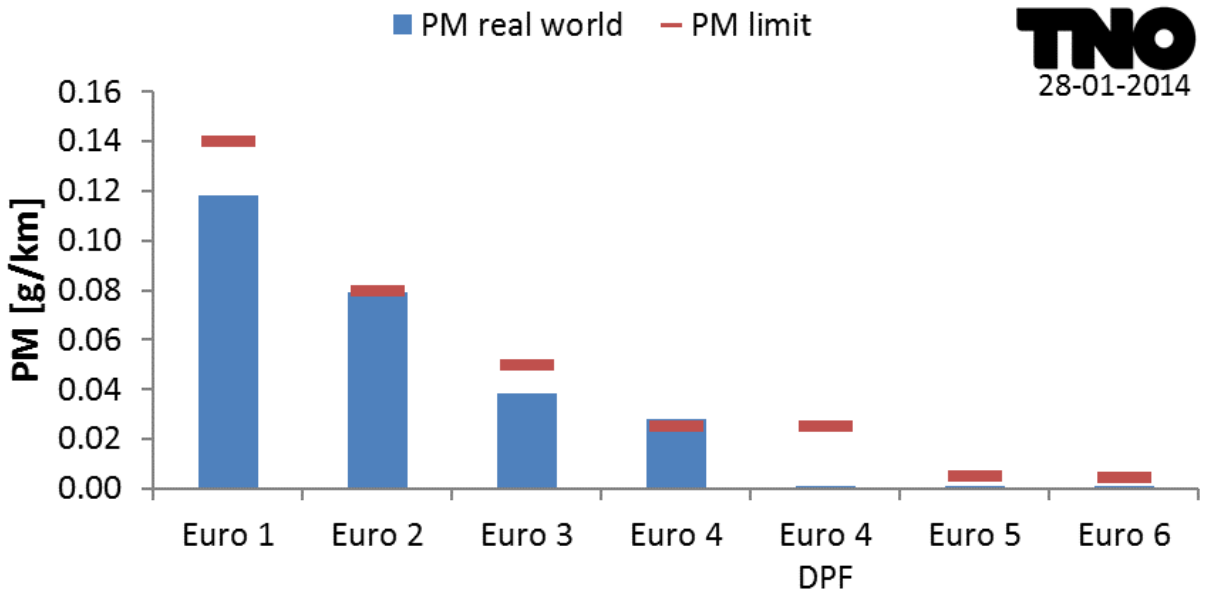
	Stakeholder	Issue or risk
1	European government	Quality of legislation, CO_2 fleet tax system
2	National government	Tax system, air quality policies
3	Type approval authority	Quality of type approval, span of control
4	Manufacturer	Quality of vehicle (on the road!)
5	Press	Dissemination and quality of information
6	Non governmental organisation	Knowledge & opinions & pressure
7	Scientist	Reliability of research & watchdog
8	Dealer - Service shop	Quality of buy & maintenance & repair
9	Fuel supplier	Fuel quality
10	Traffic controller	Vehicle speed & stop time & traffic jams
11	Vehicle owner	Governance vehicle
12	Driver	Driving behaviour
13	Citizen	**Health**

FROM VEHICLE EMISSIONS TO HEALTH IS COMPLEX

1. Fuel quality.
2. Vehicle type & technology.
3. Number of vehicles and mileages.
4. Location & Ambient conditions.
5. Propagation of the exhaust gas in ambient air.
6. Exposure to diluted exhaust gas (concentration @ frequency).
7. Breath of diluted exhaust gas.
8. Susceptibility to get sick.

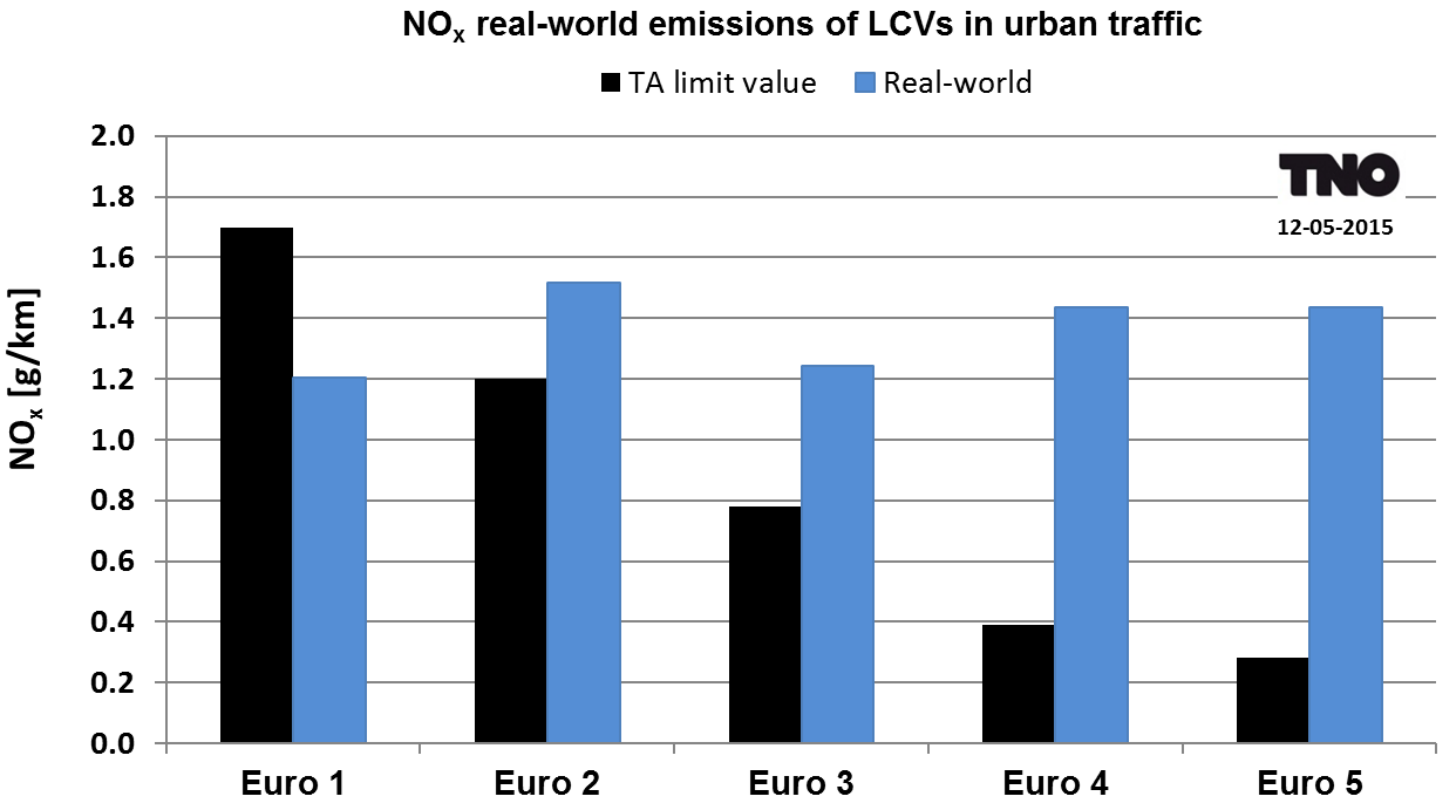
The most effective way to protect people against air pollution is a reduction of the emissions of sources.
Vehicle emissions must be as low as possible.

PM10 EMISSIONS OF LIGHT DUTY VEHICLES



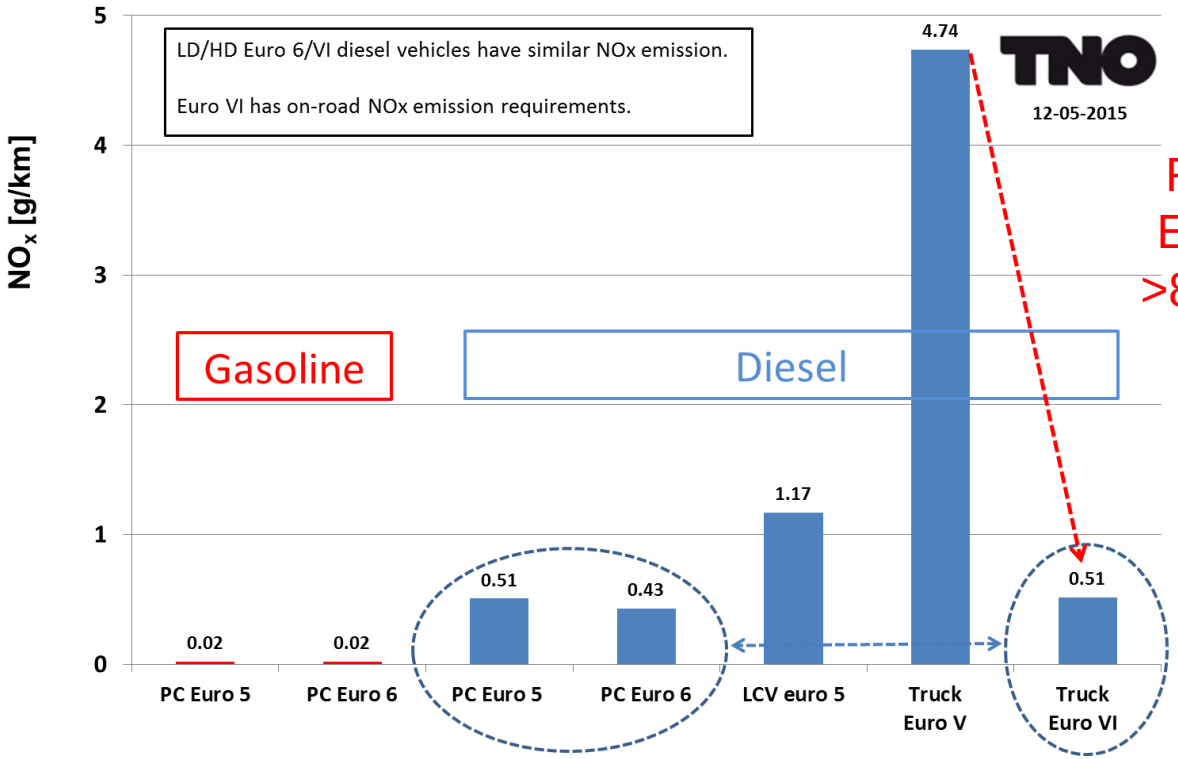
The condition of modern engines and Diesel Particulate Filters is a key issue. Suitable **tests for the Periodic Technical Inspection (PTI)** are needed. Manipulation must be avoided.

NOX EMISSIONS OF LCVS ARE STILL AN ISSUE



Emission legislation of last 25 years has no effect on real world Nox emissions in urban traffic. **Real Driving Emission legislation** is needed for an improvement.

ON-ROAD NOX EMISSIONS OF VEHICLES



RDE effect of Euro VI trucks >85% reduction

Truck RDE legislation of results in more than 85% NOx reduction.
NOx emissions of diesel passenger cars and Euro VI trucks are similar.

RISKS OF TECHNOLOGIES IN DAILY OPERATION

Emission Control System		Gasoline	Diesel	
		Passenger cars + LCV		Trucks
	Pollutant	**Euro Class**		
Exhaust Gas Recirculation (EGR, hot)	**NOx**	**2 – 6**	**4**	**III**
Exhaust Gas Recirculation (EGR, cooled)	**NOx**	**-**	**5 - 6**	**IV – VI**
Oxidation Catalyst (OC)	**CO + HC**	**1 – 4**	**3 – 6**	**IV – VI**
Three-way Catalyst (TWC)	**CO + HC + NOx**	**1 – 6**	**-**	**-**
Particulate Filter (DPF or GPF)	**PM + PN**	**6?**	**5 – 6**	**VI**
Selective Catalytic Reduction (SCR)	**NOx**	**-**	**6**	**IV - VI**
Lean NOx Trap (LNT)	**NOx**	**-**	**6**	**-**

High conversion rates (90 – 99.9 %) & high emission risks.

RISKS OF TECHNOLOGIES IN DAILY OPERATION

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		Passenger cars + LCV		Trucks
	Pollutant	**Euro Class**		
Exhaust Gas Recirculation (EGR, hot)	**NOx**	**2 – 6**	**4**	**III**
Exhaust Gas Recirculation (EGR, cooled)	**NOx**	**-**	**Elimination**	**IV – VI**
Oxidation Catalyst (OC)	**CO + HC**	**1 – 4**	**3 – 6**	**IV – VI**
Three-way Catalyst (TWC)	**CO + HC + NOx**	**1 – 6**	**-**	**-**
Particulate Filter (GPF or DPF)	**PM + PN**	**6?**	**Removal**	
Selective Catalytic Reduction (SCR)	**NOx**	**-**	**Elimination**	
Lean NOx Trap (LNT)	**NOx**	**-**	**Elimination**	**-**

Elimination, removal of parts and a lack of maintenance are the most prominent risks.

OVERVIEW CURRENT MAIN RISKS

- No ***awareness*** of the impact of air pollution on human health.
- ***Other values*** of stakeholders: Economy, mobility, status.

- ***Type approval:*** No adequate procedure which covers real world emissions.
- ***Enforcement:*** No adequate In Service Conformity Programs.
- ***Quality and representativeness of results:*** No independent testing bodies.

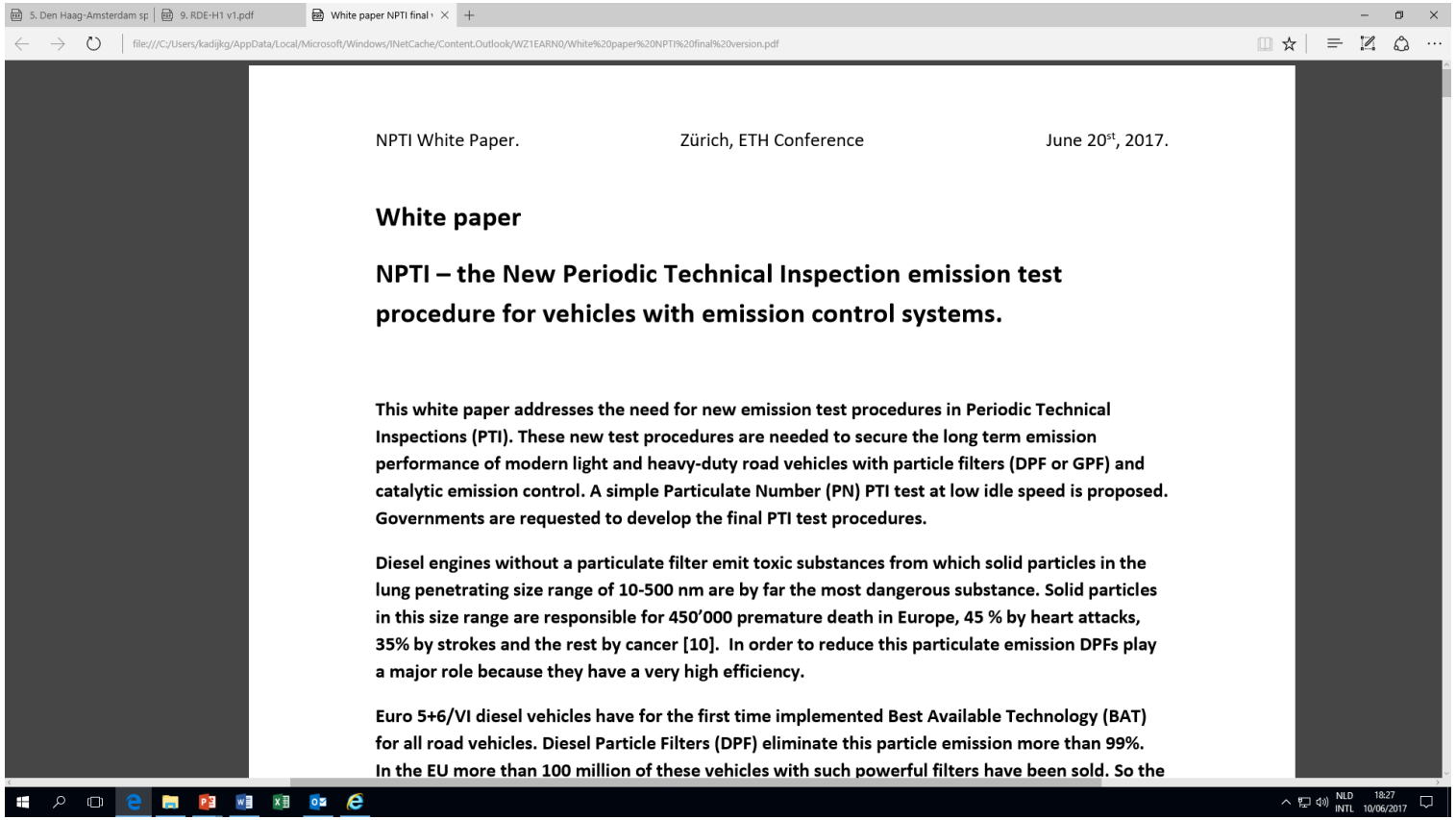
- ***Transparancy:*** *Not sufficient emission data to inform stakeholders.*
- ***Periodic Technical Inspection:*** *No adequate test procedures.*

TWO NEXT STEPS

1. New test procedures for the Periodic Technical Inspection.

2. Reliable & representative on-road emission data.

WHITE PAPER OF A NEW PERIODIC TECHNICAL INSPECTION (NPTI) FOR DPFS IS AVAILABLE.



NPTI White Paper. Zürich, ETH Conference June 20st, 2017.

White paper

NPTI – the New Periodic Technical Inspection emission test procedure for vehicles with emission control systems.

This white paper addresses the need for new emission test procedures in Periodic Technical Inspections (PTI). These new test procedures are needed to secure the long term emission performance of modern light and heavy-duty road vehicles with particle filters (DPF or GPF) and catalytic emission control. A simple Particulate Number (PN) PTI test at low idle speed is proposed. Governments are requested to develop the final PTI test procedures.

Diesel engines without a particulate filter emit toxic substances from which solid particles in the lung penetrating size range of 10-500 nm are by far the most dangerous substance. Solid particles in this size range are responsible for 450'000 premature death in Europe, 45 % by heart attacks, 35% by strokes and the rest by cancer [10]. In order to reduce this particulate emission DPFs play a major role because they have a very high efficiency.

Euro 5+6/VI diesel vehicles have for the first time implemented Best Available Technology (BAT) for all road vehicles. Diesel Particle Filters (DPF) eliminate this particle emission more than 99%. In the EU more than 100 million of these vehicles with such powerful filters have been sold. So the

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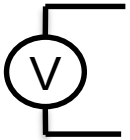
SMART EMISSION MEASUREMENT SYSTEM

Fuel consumption meter
[Litre/sec]
+- 1%

Analogue inputs
Max 16 inputs
-60 – 60 Volt
e.g. MAP, MAF



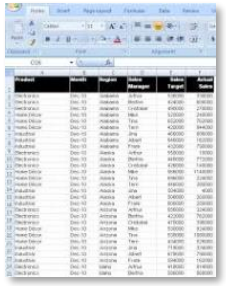
Additional NOx and O_2 or NH_3 automotive sensors

Driver feedback device
Within future plans

Standard components

SD-card memory
Up to 160.000 hours

Main unit
12V / 24V
power supply



Post-processing
Calculated values like:
- NO_x / CO_2 in [g/kg]
- fuel consumption
- NO_x, NH_3 and CO_2 [g/km]
- For HD [g/kWh]

GPRS Modem
Remote setting and data reading

GPS
5Hz
speed, altitude and position

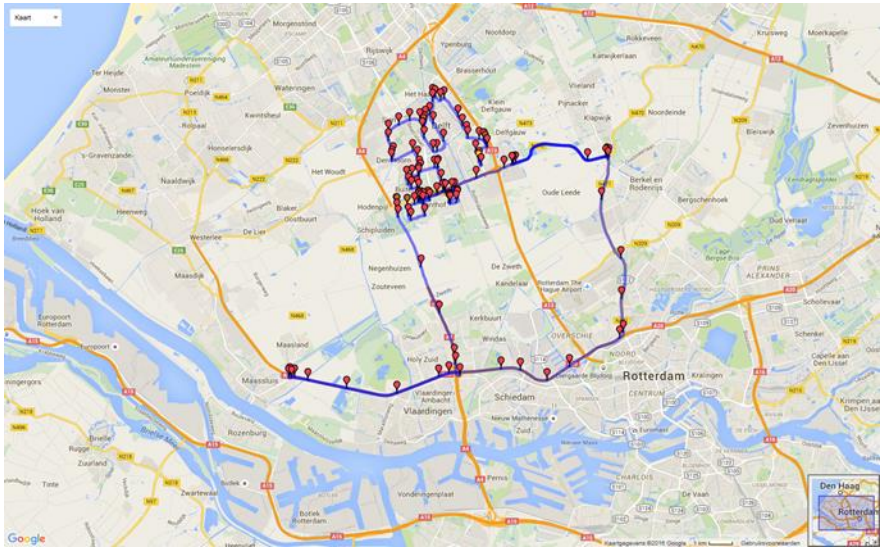
3x CAN bus interfaces
- OBDII or WWH-OBD
- J1939
- Additional CAN

NO_x / O_2/ Lambda automotive sensor
[ppm] and [v%]

NH3 automotive sensor
[ppm]

K-type thermo couples
2 pieces standard
Expandable to 18 pieces
-40 – 375 degC +- 1.5

VEHICLE + SEMS + DRIVER



RDE trip of 73 km.
Duration: 1 hr and 45 min.
SEMS stores 1 Hz data.

Result: CO_2, NOx, NH_3 [g/km]

SEMS & AUTOMATED DATA PROCESSING OF ON ROAD TEST TRIPS


THANK YOU FOR YOUR ATTENTION
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- www.tno.nl/vehicle-emissions or www.tno.nl/voertuigemissies

- https://www.tno.nl/en/focus-area/urbanisation/mobility-logistics/clean-mobility/emissions-of-particulate-matter-from-diesel-cars/