What are the steps?

How to develop policies?

Which steps are necessary?

Sacha Scheffer

Paris, 17 May 2018

Benchmarking historical fuel economies

What is a fuel economy baseline

- The fuel economy baseline is the weighted average fuel economy of all vehicles registered for the first time in a given year in a country

- The weighted average fuel economy is calculated using model specific fuel economy values and the number of registered vehicles as weight

- Typically, the baseline is set on vehicles registered for the first time

Status for main road modes

2/3 wheelers

- UN regulation for FE/emission measurement are in place
- China is the only country having mandatory FE standards for two wheelers in place (implemented 2009)
- FE data not easy to get from public sources

Our focus in this session

Light duty vehicles (passenger cars)

- **UN regulation for FE/CO_2 emission measurement are in place**
- **Testing procedures have a long history**
- **FE policies widespread**
- **FE data is relatively easy to get from public sources**

Heavy duty vehicles

- Large variety of HDV models and mission profiles
- More complex than LDVs, requires dedicated software
- FE policies only in 4 countries
- UN regulation for FE/CO_2 emission measurement yet

Minimum data requirements

- Vehicle make and model (e.g. Toyota Corolla)
- Year of first registration
- Model production year (important for used imports)
- Engine displacement (liters or cubic centimeters)
- Engine power (kW or HP)
- Fuel type (e.g. gasoline, diesel, LPG, CNG, electricity)

- Number of vehicles registered
- Rated fuel economy (Lge/100km, alternatively CO_2 emission, gCO_2/km) and test cycle (NEDC, FTP, JC08)

Nice to have…

- Transmission type (automatic, number of gears)
- Vehicle footprint (wheelbase x track width)
- Vehicle weight (mass in running order)
- Axle configuration (4x2, 4x4)
- Vehicle price

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Once you have the data…

How to get from the vehicle registration database to your benchmark?

- Sales weighted average FE

$$FE = \frac{\sum_i^n Sales_i \times FE_i}{\sum_i^n Sales_i}$$

Country	Year	Vehicle Type	Model	Engine ccm	Engine kW	Fuel type	Transmission type	Emission standard	Vehicles registered	Final FE data, lge/100km
xxx	2013	Pass.	VW Polo	1199	55	Diesel	Manual	EURO5	614	4.1
xxx	2013	Pass.	VW Polo	1199	55	Diesel	Manual	EURO5	512	3.7
xxx	2013	Pass.	Renault Clio	1461	55	Diesel	Manual	EURO5	1474	3.9
xxx	2013	Pass.	Renault Clio	1461	55	Diesel	Manual	EURO5	1448	4.1
xxx	2013	Pass.	Renault Clio	1461	55	Diesel	Manual	EURO5	1140	4.3
xxx	2013	Pass.	Suzuki Grand Vitara	1870	[illegible]	Diesel	Manual	EURO5	217	7.5
xxx	2013	Pass.	Jaguar X[illegible]	2179	147	Diesel	Automatic	EURO5	20	5.8
xxx	2013	Pass.	Audi A7	2967	180	Diesel	Automatic	EURO5	37	6.5
xxx	2013	Pass.	Audi A7	2967	180	Diesel	Automatic	EURO6	29	6.4
xxx	2013	Pass.	BMW 535	2993	230	Diesel	Automatic	EURO6	2	6.0
xxx	2013	Pass.	BMW 535	2993	230	Diesel	Automatic	EURO5	1	6.2
xxx	2013	Pass.	Jeep Grand Cherokee	2987	184	Diesel	Automatic	EURO5	97	8.1
xxx	2013	Pass.	BMW X6	2993	180	Diesel	Automatic	EURO5	61	8.0
xxx	2013	Pass.	Citroen C5	1560	84	Diesel	Manual	EURO5	286	5.2
xxx	2013	Pass.	Citroen C5	1560	84	Diesel	Automatic	EURO5	247	4.8

How to get the data

- Who owns the data we need?
  Can the data be shared?
  - ➢ Need for cooperation with relevant stakeholders
- What institutional framework is needed to continuously collect and develop data?
  - ➢ Need for legal framework to enable access to information

- Vehicle market structure
  - Is the share of used imported vehicles significant?
  - ➢ Implications on stakeholders involved and data availability

Baseline setting challenges

- Level of detail available
  - Accuracy depends on level of detail
- Quality of the data available
- Used imports vs. new sales
- Availability of alternative sources to fill gaps, example: FE data by model
  - FE data: EEA, EPA, Chinese government website

- **How to get FE data if there are missing information?**

  - There are opportunities to rely on data from publicly available datasets (developed thanks to a legal framework imposing it…)

Country	Data source
Australia	http://www.greenvehicleguide.gov.au/
Austria	http://www.autoverbrauch.at/ireds-133453.html
Brazil	http://pbeveicular.petrobras.com.br/TabelaConsumo.aspx
Canada	http://oee.nrcan.gc.ca/fcr-rcf/public/index-e.cfm
Chile	http://www.consumovehicular.cl/
China	http://chinaafc.miit.gov.cn/n2257/n2280/index.html
European Union	http://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-10
France	http://www.ademe.fr/consommations-carburant-emissions-co2-vehicules-particuliers-neufs-vendus-france
Germany	http://www.pkw-label.de/autokauf/tool-neufahrzeuge-finden.html#/suche
India	http://www.siamindia.com/uploads/filemanager/256th-4W-FE-Data-Declaration.pdf
Japan	http://www.mlit.go.jp/jidosha/jidosha_fr10_000019.html
Korea	http://bpms.kemco.or.kr/transport_2012/main/main.aspx
Mexico	http://www.ecovehiculos.gob.mx/
New Zealand	https://www.energywise.govt.nz/tools/fuel-economy/
Saudi-Arabia	http://www.sls.gov.sa/Pages/ar/Consumer/FEManufacturers.aspx
Singapore	https://vrl.lta.gov.sg/lta/vrl/action/pubfunc?ID=FuelCostCalculator
South Africa	http://www.naamsa.co.za/ecelabels
Switzerland	http://katalog.automobilrevue.ch/
United Kingdom	http://carfueldata.direct.gov.uk/
United States	http://www.fueleconomy.gov/feg/download.shtml

Data quality & gaps

- **How to get FE data if there are missing information?**

➢ The larger the number of variables available, the more accurate will be the baseline estimate…

Country	Year	Vehicle Type	Model	Engine ccm	Engine kW	Fuel type	Transmission type	Emission standard	Vehicles registered	Final FE data, lge/100km
xxx	2013	Pass.	VW Polo	1199	55	Diesel	Manual	EURO5	614	4.1
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Important to account for test cycle and conversion methods

- 2 drive cycles currently used:
  - Europe – NEDC, United States – CAFE, Japan – JC08
- Identical cars show different fuel economy values under different test conditions (up to 20% difference)
- Results need to be normalized

Gasoline	Unit: gCO_2 per km	NEDC to CAFE	CAFE	=	0.8658	*	NEDC	+	14.076
		CAFE to NEDC	NEDC	=	1.1325	*	CAFE	-	13.739
		JC08 to CAFE	CAFE	=	0.7212	*	JC08	+	36.736
		CAFE to JC08	JC08	=	1.2749	*	CAFE	-	38.423
		JC08 to NEDC	NEDC	=	0.8457	*	JC08	+	24.840
		NEDC to JC08	JC08	=	1.1430	*	NEDC	-	24.907
Diesel	Unit: gCO_2 per km	NEDC to CAFE	CAFE	=	0.7683	*	NEDC	+	23.928
		CAFE to NEDC	NEDC	=	1.2209	*	CAFE	-	21.218
		JC08 to CAFE	CAFE	=	0.6050	*	JC08	+	44.338
		CAFE to JC08	JC08	=	1.3691	*	CAFE	-	38.393
		JC08 to NEDC	NEDC	=	0.8230	*	JC08	+	21.950
		NEDC to JC08	JC08	=	1.1720	*	NEDC	-	21.122

Data quality & gaps

- **Important to account for same energy content of fuels**
- The first conversion factor accounts for the different energy densities of gasoline and diesel to convert L/100km to LGE/100km
- The retrofit adjustment accounts for the efficiency losses of cars when retrofitted to LPG or CNG.

L/100km to Lge/100km	Diesel	FE*1.08
Retrofit adjustment	CNG	FE*1.12
	LPG	FE*1.15

Is this just about benchmarking?

- No: the same calculations allow you to **monitor progress** over time!
- Setting up the necessary legal requirements is not just for a one-of type of efforts
- These same data are very useful to:
  - Develop fuel economy standards
  - Monitor their progress
  - Develop fiscal measures (feebates, differentiated taxes)
  - Monitor their development and revise the policy over time

Setting targets

Need for cost-benefit analysis

Impact assessment: accounting for the effect of a policy, taking into considerations costs and benefits

- Compliance costs
  - Auto and fuel industries
- Health benefits
  - Reductions in local air pollutants
- Climate benefits
  - Reductions in carbon emissions
- Oil savings
  - Including improved energy security

Challenges

- Benefits are more complicated to estimate than costs
  - Some climate variables are difficult to quantify and/or monetize
- Direct impacts (vehicle costs vs. fuel savings are a good start)
  - Co-benefits can further support the results
- Payback time often use as criterion for determining policy ambition

- Payback time function of several parameters
  - Technology cost
  - Fuel saving potential of technologies
  - Fuel cost (including taxes…)
  - Vehicle mileage (the more you travel, the more an energy efficient technology will allow you to save…
- Some examples

Rule	Per-Vehicle Cost	Payback Period
US LDV 2017–2025[1]	$1,800	3.5 years
US LDV 2012–2016[2]	$950	3 years
US HDV Phase 1 2014 – 2017[3]	$378–$6,215	1–2 years
California Advanced Clean Cars Program 2017 – 2025[4]	$1,340–$1,840	3 years
Canada LDV 2017-2025[5]	$2,095	2 to 5 years
Canada LDV 2011-2016[6]	$1,195	1.5 years
European 95g CO_2/km Standard 2020[7]	€1,300	4-5 years
India LDV 2020[8]	$400 to $600	2–3 years

Source: ICCT, 2015

Ex-post results in European Union (2009 → 2015)

- CO_2 Regulation is likely to have accounted for 65- 85% of the reductions in tailpipe emissions achieved following the introduction of the Regulation
- The Regulations were found to have been more successful in reducing CO_2 emissions compared to voluntary agreements from industry, which achieved an estimated rate of annual improvement in CO2 of 1.1 to 1.9 gCO_2/km compared to the rate achieved by the Regulations of 3.4 to 4.8 gCO_2/km
- In terms of efficiency both of the Regulations have generated net economic benefits to society. The car CO_2 Regulation has abatement costs of **-€46.4** per t of CO_2 abated
- Costs to manufacturers have been much lower than originally anticipated, because emissions abatement technologies have, in general, proved to be less costly than expected

Source: https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/evaluation_ldv_co2_regs_en.pdf

Monitoring, compliance and enforcement

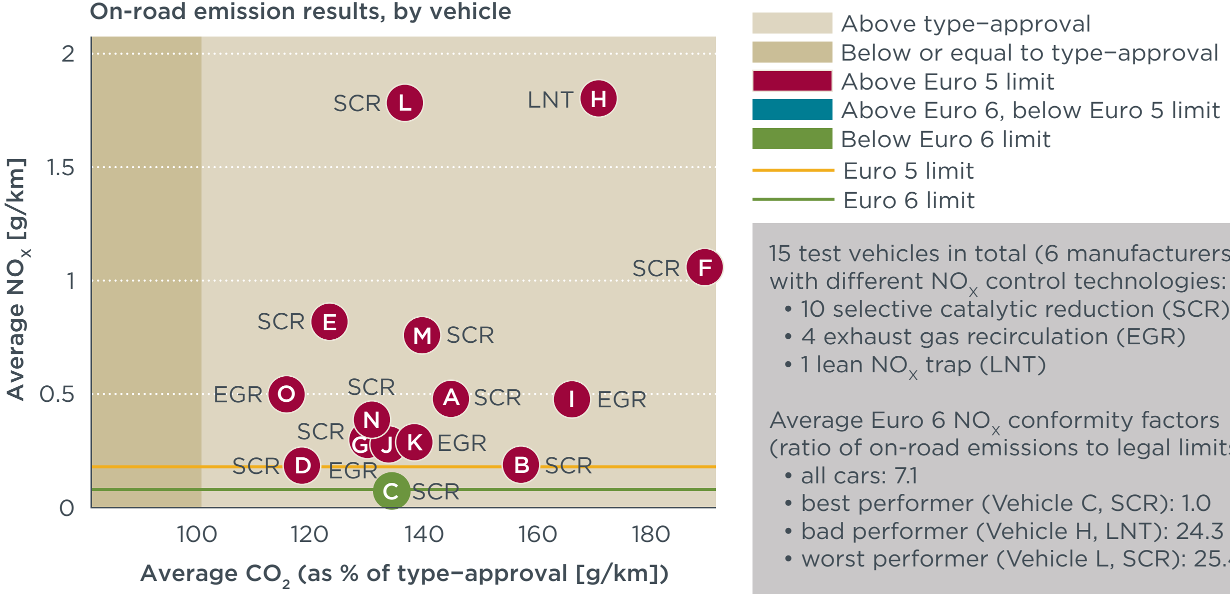
Key Messages

- Lack of adequate government resources and legal authority to ensure compliance with motor vehicle emission standards is a major challenge worldwide.
- This situation applies to real world emissions of all pollutants (e.g., NOx, CO_2), light and heavy-duty vehicles, and diesel and petrol vehicles.
- Dieselgate continues to be a "wake up call" - highlighting major deficiencies in government programs to ensure compliance with emission standards.
- For purposes of this presentation, non-compliance is used broadly to mean excessive real world emissions independent of legality with the law.
- Europe is highly relevant to these discussions because of its status as the de facto standard setter for most countries outside of the US and Japan.
- Much progress is underway in key markets, but there is much more to accomplish.

Real-world exhaust emissions from diesel cars

ICCT White Paper:
Real-world exhaust emissions from modern diesel cars: A meta-analysis of PEMs emissions data from US and EU passenger diesel cars (October 2014)

Average on-road emissions of NO_X and CO_2, by vehicle



15 test vehicles in total (6 manufacturers), with different NO_X control technologies:

- 10 selective catalytic reduction (SCR)
- 4 exhaust gas recirculation (EGR)
- 1 lean NO_X trap (LNT)

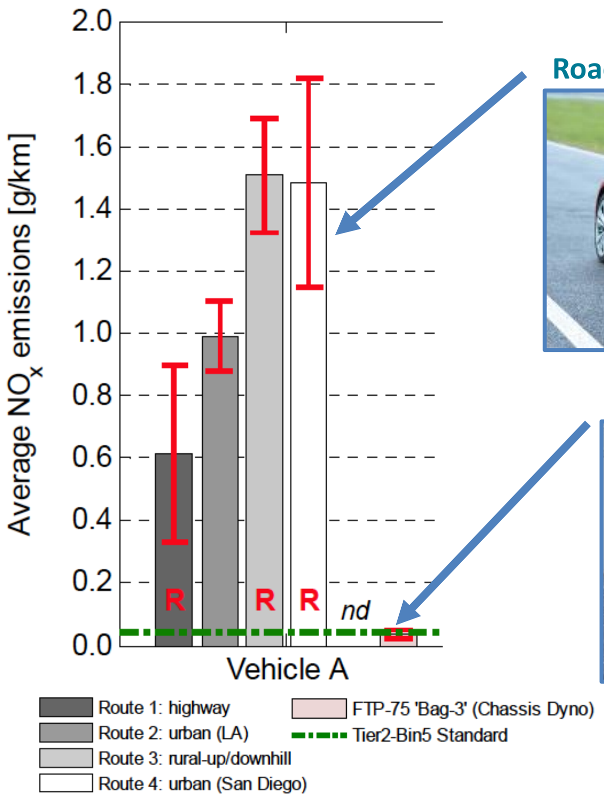
Average Euro 6 NO_X conformity factors (ratio of on-road emissions to legal limits):

- all cars: 7.1
- best performer (Vehicle C, SCR): 1.0
- bad performer (Vehicle H, LNT): 24.3
- worst performer (Vehicle L, SCR): 25.4

http://www.theicct.org/real-world-exhaust-emissions-modern-diesel-cars

Real world testing of diesels in U.S. led to action

Real world testing of light duty diesels in U.S. led to CARB / EPA investigations and legal action



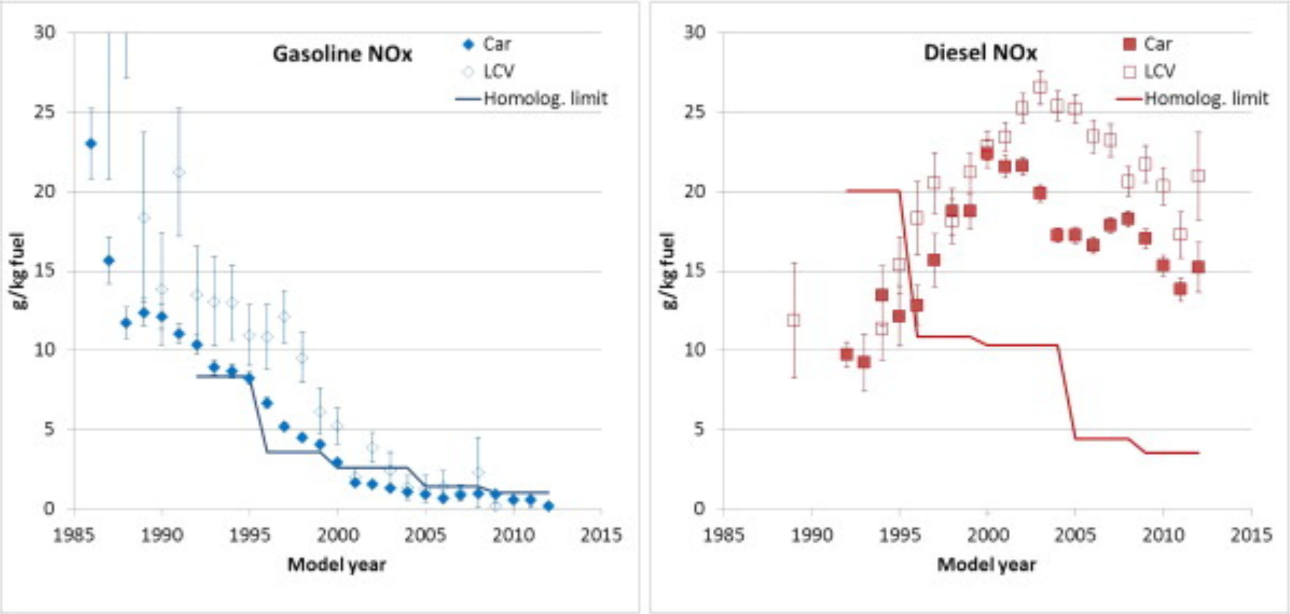
Road tests with PEMS

Chassis dyno measurements

Photo credit: AVL / ERMES Group
Vehicle photos unrelated to the results shown

http://www.theicct.org/use-emissions-testing-light-duty-diesel-vehicles-us

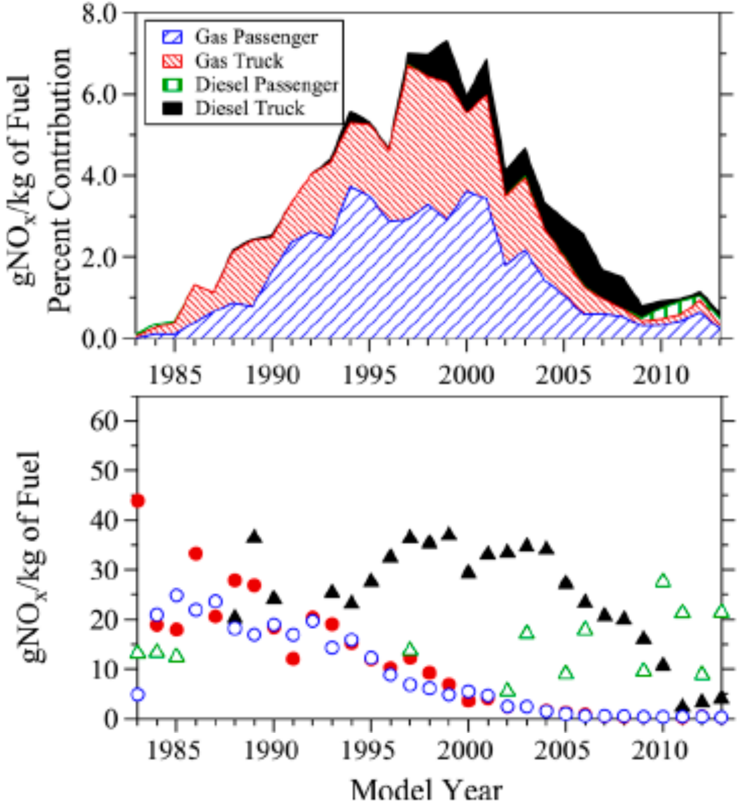
Remote sensing data shows historic trends in NOx emissions from diesel and petrol cars in Switzerland



Chen & Borken-Kleefeld, Real-driving emissions from cars and light commercial vehicles - Results from 13 years remote sensing at Zurich/CH Atmospheric Environment, 88:157-164 (May 2014)

Further findings from remote sensing

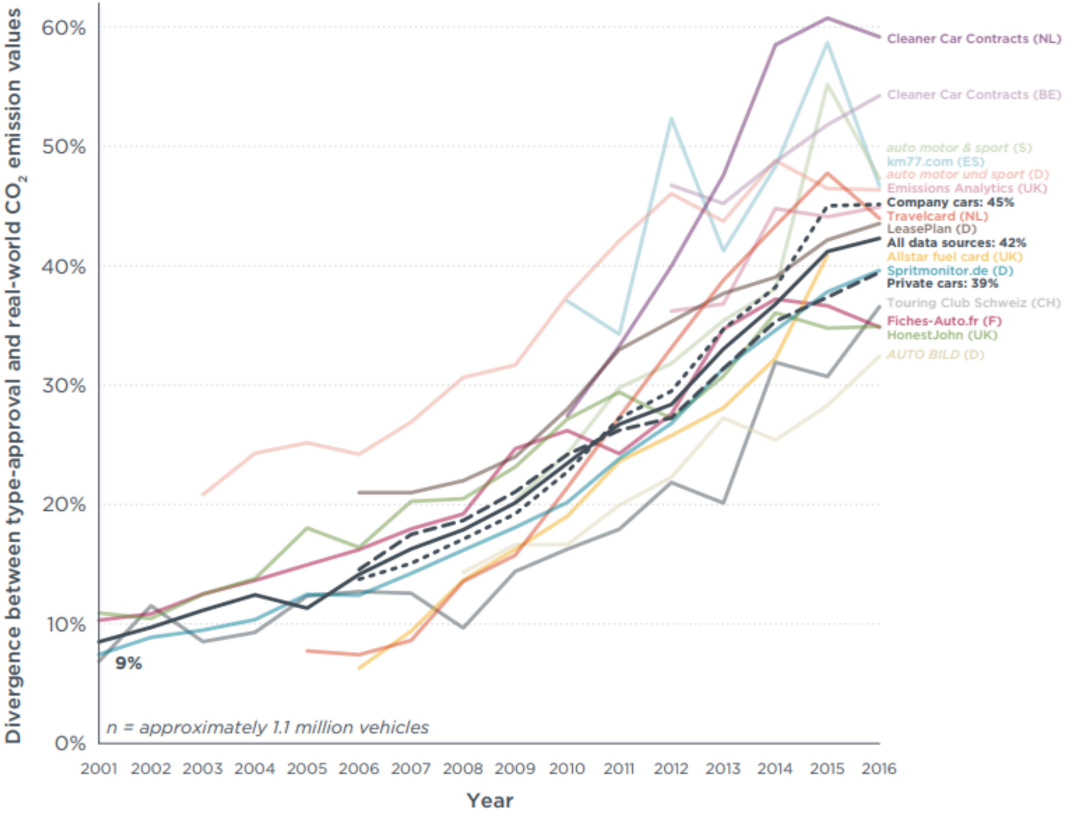
Remote sensing provided evidence of gross noncompliance by HDVs in U.S. in 1990s



Adapted from Bishop & Stedman. Env. Sci. and Technol. (2015)

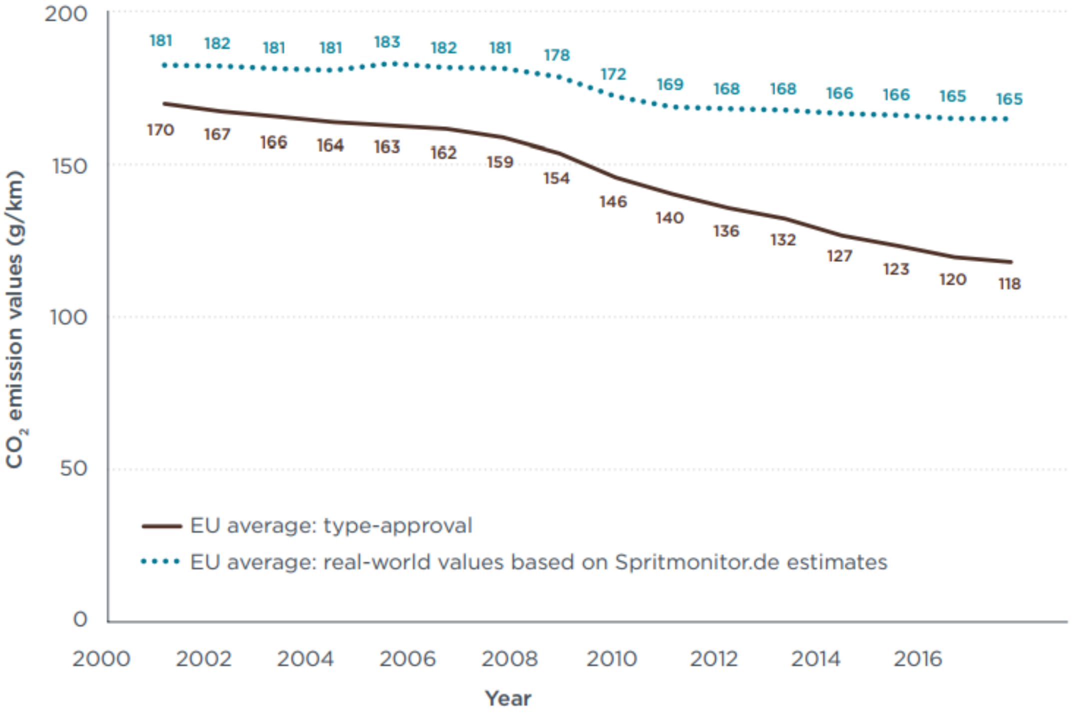
It’s not just about NOx . . .

Real-world CO_2 in EU is 30+% higher than claimed



https://www.theicct.org/sites/default/files/publications/Lab-to-road-2017_ICCT-white%20paper_06112017_vF.pdf

Growing gap in real world v. type approval emissions cut expected gains from European CO_2 standards more than half.



Tested: 30% CO_2 reduction

Real world: 10% CO_2 reduction

https://www.theicct.org/sites/default/files/publications/Lab-to-road-2017_ICCT-white%20paper_06112017_vF.pdf

Compliance Regimes in the US and Europe

- **Test cycles and protocols**
- **Recall and penalty authority and actions**

ICCT White Paper - The future of vehicle emissions testing and compliance (November 2015)

- Objective is to compare and contrast the current vehicle testing and compliance schemes in the EU and the United States.
- The fundamental difference is not so much actual vehicle testing but the strong focus on independent conformity testing coupled with enforcement authority in the US.
- In the EU, by contrast, this element of independent re-testing is largely absent from the regulations, and the involved regulatory bodies are more restricted with respect to their enforcement authority.


WHITE PAPER NOVEMBER 2015

THE FUTURE OF VEHICLE EMISSIONS TESTING AND COMPLIANCE

HOW TO ALIGN REGULATORY REQUIREMENTS, CUSTOMER EXPECTATIONS, AND ENVIRONMENTAL PERFORMANCE IN THE EUROPEAN UNION

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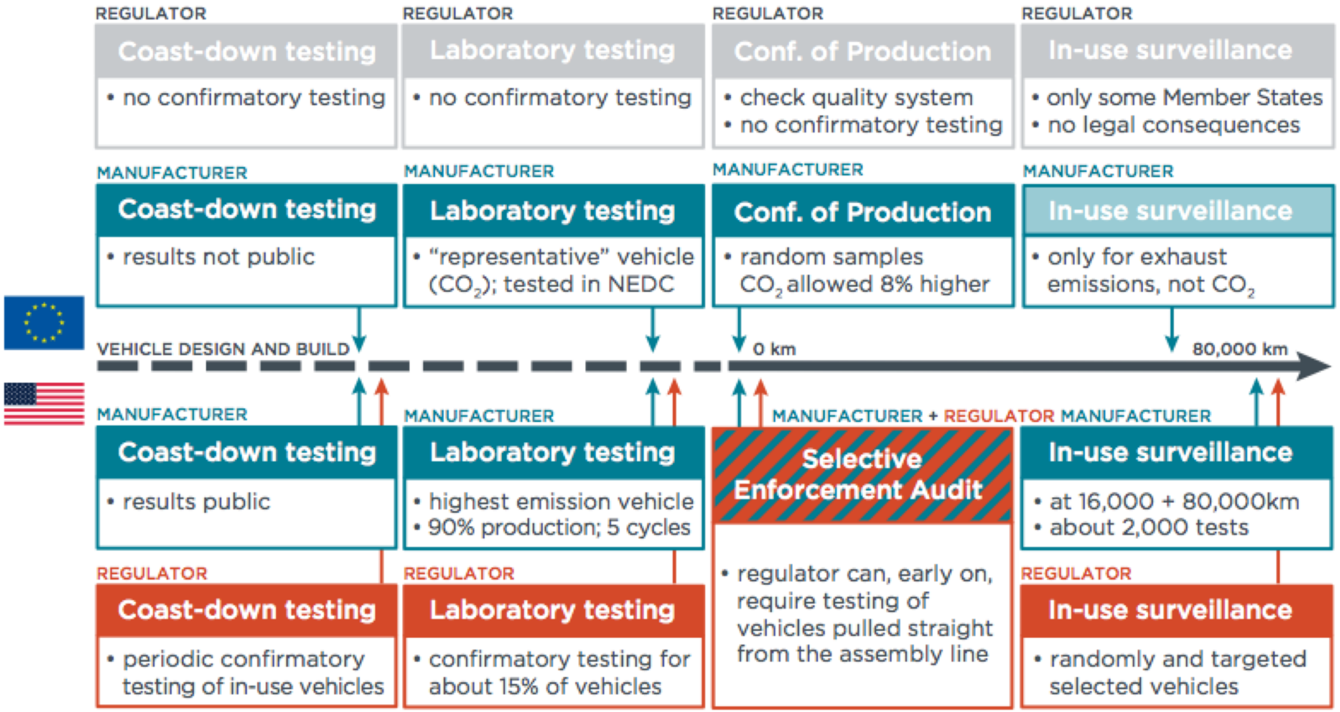
http://www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf;

US v EU Compliance Systems



Historically, about 3 million recalls annually
in the US (~ 1% of total vehicle population @ 250 million)

Guidelines for Effective Compliance Programs

1. **Certification testing** – The test cycle must be representative of real world driving, and test procedures must help ensure that test conditions match normal driving situations.
2. **Real world testing** – As a check on representative nature of the certification test, and to identify defeat devices, real world testing is essential. Europe is developing a “real world driving emission” test protocol and EPA and CARB now include random real world testing as part of certification testing.
3. **Vehicle recalls** – Recall authority is an essential element of effective enforcement. Historically, EPA issues 3 million recalls each year.
4. **Data transparency** – All certification test results, recalls and penalties should be publicly available. Most is available in the US, very little is available elsewhere.
5. **Warranty** – Manufacturers should be required to guarantee to the consumer that emission control technologies are effective and durable over vehicle lifetime (e.g., In the U.S., it’s currently 8 years or 80,000 miles).
6. **Financial penalties** – Financial penalties should be large enough to deter illegal behavior (e.g., US and China – and proposed in Europe – penalties at $30 – 40,000 per vehicle).
7. **Political autonomy** – Government officials responsible for taking decisions that affect major corporations must be shielded from political influence.
8. **Resources** – US EPA and CARB have long-established compliance programs with substantial technical capabilities, expert staff, and strong legal authority that will be challenging to replicate in the rest of the world.

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