DIAS

SMART ADAPTIVE REMOTE DIAGNOSTIC ANTITAMPERING SYSTEMS

Anti-tampering guidelines (WP6 + WP3) & Impact Assessment (WP6)

25th October 2022, Brussels

HORIZON 2020
LC-MG-1-4-2018
Grant agreement ID: 814951

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Smart Adaptive Remote Diagnostic Antitampering Systems

EUROPEAN COMMISSION
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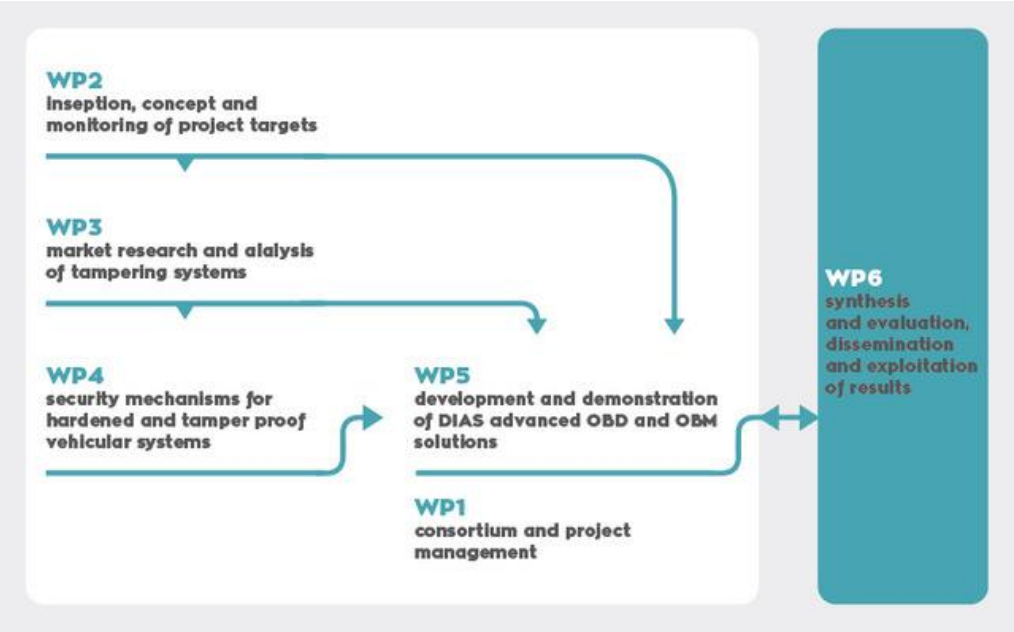
  - Methodology and targets
  - Other end-users' guidelines
  - OEMs' guidelines
    - Functional requirements for the Type Approval of new vehicles
    - Functional requirements for the management of the threats, the countermeasures and the inducement of vehicles in-service
- **Impact Assessment**
  - Modelling method and inputs to tampering modelling
  - Environmental and health impacts → Potential benefits from anti-tampering legislation
- **Q&A**



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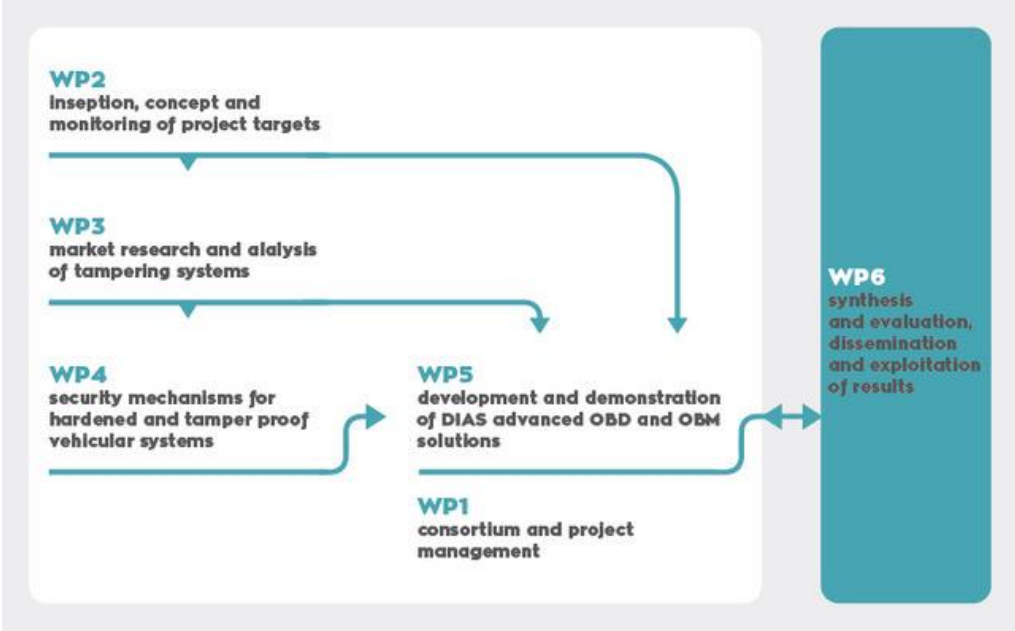

Objective

Overall objective:

To prevent, detect and report any tampering strategies during the entire life of the vehicle.

- We need to recognize that no vehicle can be made 100% tamper-proof
- Regulatory framework should aim to make it not cost-effective to develop and apply tampering strategies

Legislative framework

- Recommended approach:
  - *Ex-ante:*
    Embedded in the TA process - to prevent against foreseeable tampering
  - *Ex-post:*
    Continued obligation for monitoring - to prevent against new tampering strategies on future new generations of vehicles and in-service vehicles
- Apply functional requirements rather than technical requirements to tackle unforeseen tampering strategies

Basic targets of anti-tampering guidelines

- DIAS market and risk analysis, and technical solutions are leveraged to **recommend regulatory provisions:**
  - **For vehicle manufacturers:**
    - For Type Approval of new vehicles
    - After the Type Approval for future vehicles in-service
  - **For many other end-users:**
    - Member states' guidelines
    - Periodic Technical Inspection centers' guidelines
    - Roadside Inspection authorities' guidelines
    - ISC and MaS authorities' Guidelines
    - Workshops' guidelines
    - Vehicle owners' guidelines

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Guidelines for the other (non-OEMs) end users

- **Member States**: 
  - Prohibition and relevant fines for use, execution, or trade of tampering-related devices, services, and practices and liability definition in each case
  - Legislating and enforcement of tampering-relevant checks and reporting by roadworthiness inspections
  - Enforcement to report any tampering case and provision of reporting options
- **PTI centres and RSI authorities**:
  - Advanced emission measurement techniques for all regulated pollutants
  - Advanced visual inspections
  - Access and evaluation of tampering-related data
  - Reporting of tampered vehicles
  - Enforcement actions

Guidelines for the other (non-OEMs) end users

- **Workshops**: 
  - Expansion of the SERMI* scheme to protect access to EPS-related information
  - Voluntary submission of tampering-related information
- **ISC, MaS, (Remote Sensing) authorities**: 
  - Advanced visual inspections
  - Reporting of tampered vehicles
  - Reporting of vehicles with high emissions but with inactive MIL to be further investigated by TAA or PTI centers)
- **Vehicle owners**: 
  - Burdened with fines, costs for EPS reversion to its original form, testing costs or other penalties if liable for any tampering case

OEMs' responsibilities for Type Approval (**ex-ante**)

- Proposed functional requirements for the **Type-approval of new vehicles → Vehicle manufacturers should:**

1. Perform a Threat Assessment and Risk Analysis (TARA), and market analysis for:
- Components (sensors, control units): flashed, emulated, modified
- In-vehicle communication/data exchange: no integrity, no authenticity
- Vehicle-to-Infrastructure (V2I) communication/data exchange

2. Develop countermeasures for prevention and detection which must:
- Cover the fundamental requirements which have been identified by DIAS
- Be proportional based on the TARA
- Be adaptable based on the market analysis

3. Provide tampering-related reporting methods for:
- In-vehicle reporting (e.g. MIL-type)
- V2I reporting (e.g. reporting to a cloud infrastructure)

4. Develop methods for inducement and enforcement of repair

5. Demonstrate/declare conformity with the legislative requirements

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OEMs' responsibilities for Type Approval (ex-ante)
TARA

- OEMs should conduct a TARA combined with a market analysis, addressing all known (both hardware- and software-related) attacks for their Environmental Protection Systems (EPS)
- TARA should be based on **ISO/SAE 21434** incorporating the following proposals/improvements:

TARA generic module (based on ISO/SAE 21434)	**Modifications/adaptations needed for TARA performed in EPSs**
Asset identification	-
Threat scenario identification	-
Impact rating	**Additional impact category:** E.g. "Environmental impact"
Attack path analysis	-
Attack feasibility rating	• **The attack potential-based approach** should be followed • **Additional attack feasibility parameter:** E.g. "Financial motive"
Risk value determination	-
Risk treatment decision	-

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OEMs' responsibilities for Type Approval (ex-ante)
Diagnostic and security countermeasures

Diagnostic (tampering detection) and ***security*** (tampering prevention) countermeasures to be applied from OEMs

- Fundamental countermeasures*
  - Secure data exchange between SCUs (for direct emission sensing for regulated species) and ECU
  - Secure flashing (boot, SW update, transfer of certificates, and tester authentication)
  - Frequent FCM clear detection
  - Identification of executed software
  - Calculation of tampering indicator value
- Countermeasures addressing the requirements derived from TARA and market analysis

*Measures targeting the tampering attacks that already cover a significant market share, lead to significant increase in exhaust emissions and are independent of the EPS (Environmental Protection System) technology

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OEMs' responsibilities for Type Approval (ex-ante) Reporting

- <u>In-vehicle reporting (i.e. MIL)</u> *(note: this is also part of the inducement):*

  - MIL status could be upgraded to **incorporate the tampering indicator value**
  - Additional checks of EPS state of health and a link to an inducement system (CLOVE suggestion for new MIL) → The tampering indicator value should be also considered as part of the EPS state of health

- <u>Vehicle-to-Infrastructure (V2I) reporting</u>:

  - **Provide secure V2I tampering-related data transmission** in case the latter is requested from existing or future regulated V2I reporting activities (e.g. OBFCM). In this cases:
    - Anti-tampering security measures justified from TARA and market analysis should be applied
    - Transferring/reporting tampering-related data can be applied:
      - Tampering indicator value or upgraded MIL status
      - ECU data verification status
      - Secure SW and calibration identifier (i.e. upgraded CVN)

OEMs' responsibilities for Type Approval (ex-ante) Inducement

- Target: hinder tampering attempts or mandate the owner of the vehicle to reverse any tampering attempt
- MIL (which incorporates the tampering indicator value) to be linked to the warning and inducement system in a way that the severity of inducement is proportional to emissions level and tampering probability estimation
- <u>Examples:</u>
  - **Low** tampering indicator value:
    - Inducement system: Disabled
    - Warning system: Informs the driver to check the malfunction on the next service appointment or the next PTI
  - **High** tampering indicator value: the inducement system will be enabled and the warning system will indicate the driver to act immediately.
    - Inducement system: Enabled
    - Warning system: Informs the driver to act immediately

OEMs' and **TAAs'** responsibilities for Type Approval (ex-ante) Declaration of conformity

- OEM shall provide an information package to the type approval authority (TAA) and a declaration on fulfillment of the requirements.
- The TAA has the mandate to ask for dedicated demonstration tests, including reporting of the MIL in the case that tampering is detected by the vehicle.
- For such demonstration tests there are no test procedures in place since the TAA should have the freedom to request any kind of demonstration, tailored to the specific technologies of the emission control system applied.

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OEMs' and TAA responsibilities after Type Approval (**ex-post**)

- **OEMs:**
  - Apply vulnerability management
  - Follow up on:
    - Evidences and information from the tampering market
    - Feedback from vehicle dealers/workshops
    - Feedback from periodical technical inspections (PTI)
    - Test results from in-service conformity testing or market surveillance tests (ISC and MaS)
    - Road-side inspections
  - Repeat the TARA and develop/update the countermeasures to mitigate the new threats
- **TAA**:
  - Require OEMs to address new vulnerabilities with appropriate countermeasures based on an impact assessment

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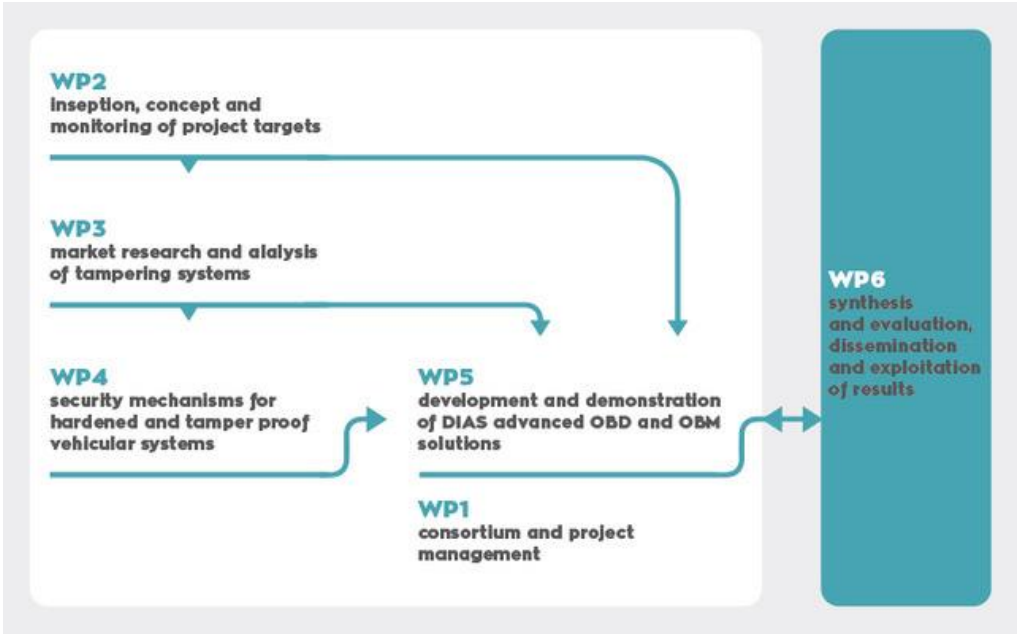
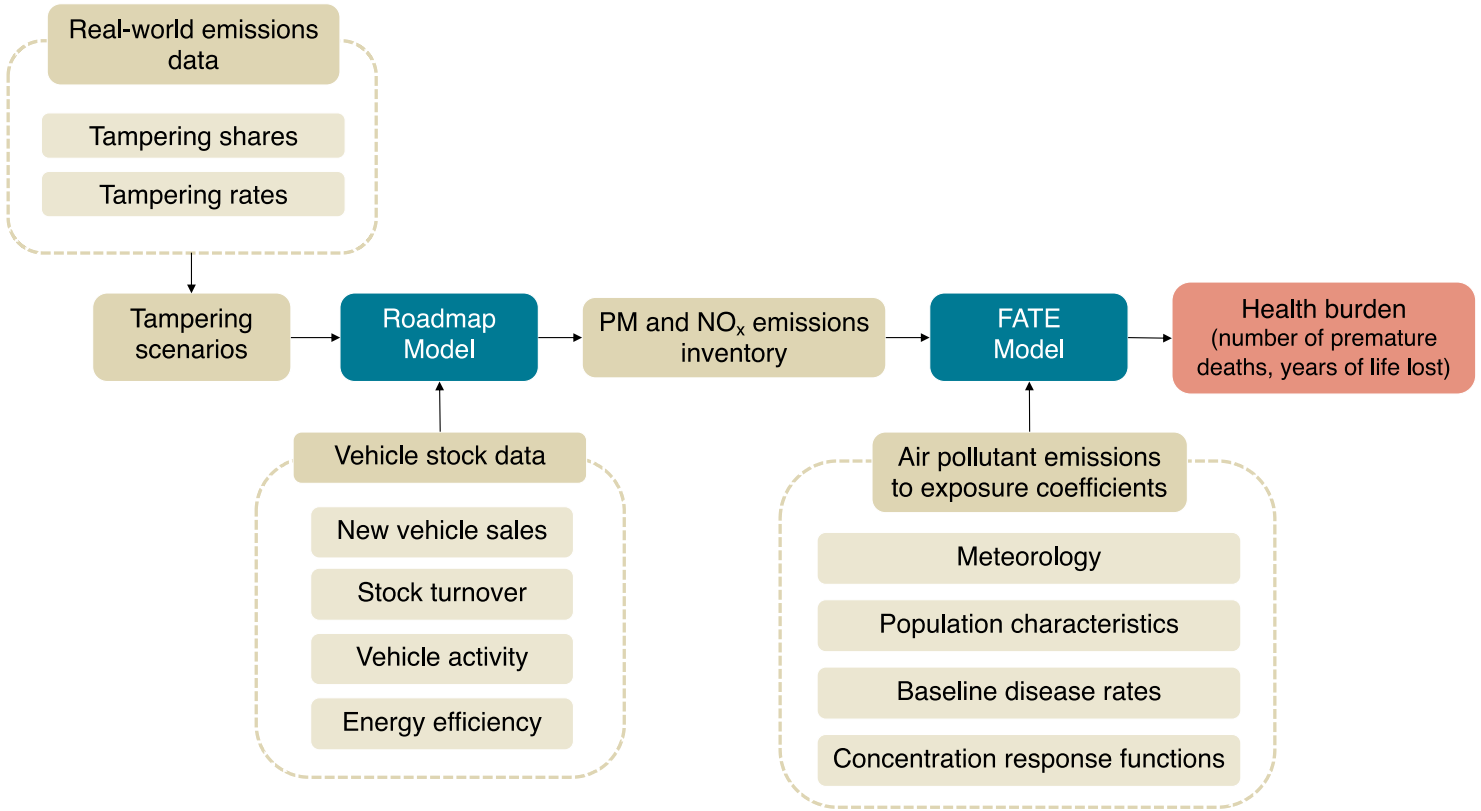


Modelling methodology

Estimating the health impacts of tampering:

1. Estimation of total NOx and PM emissions from the EU on-road vehicle fleet out to 2050, and share attributable to tampering (ICCT's Roadmap Model)[1]

2. Estimation of the air quality and health impacts resulting from additional emissions due to tampering (ICCT's FATE Model)[2]



[1] The International Council on Clean Transportation. ICCT's Roadmap Model Documentation (version 1.5), 2021. https://theicct.github.io/roadmap-doc/

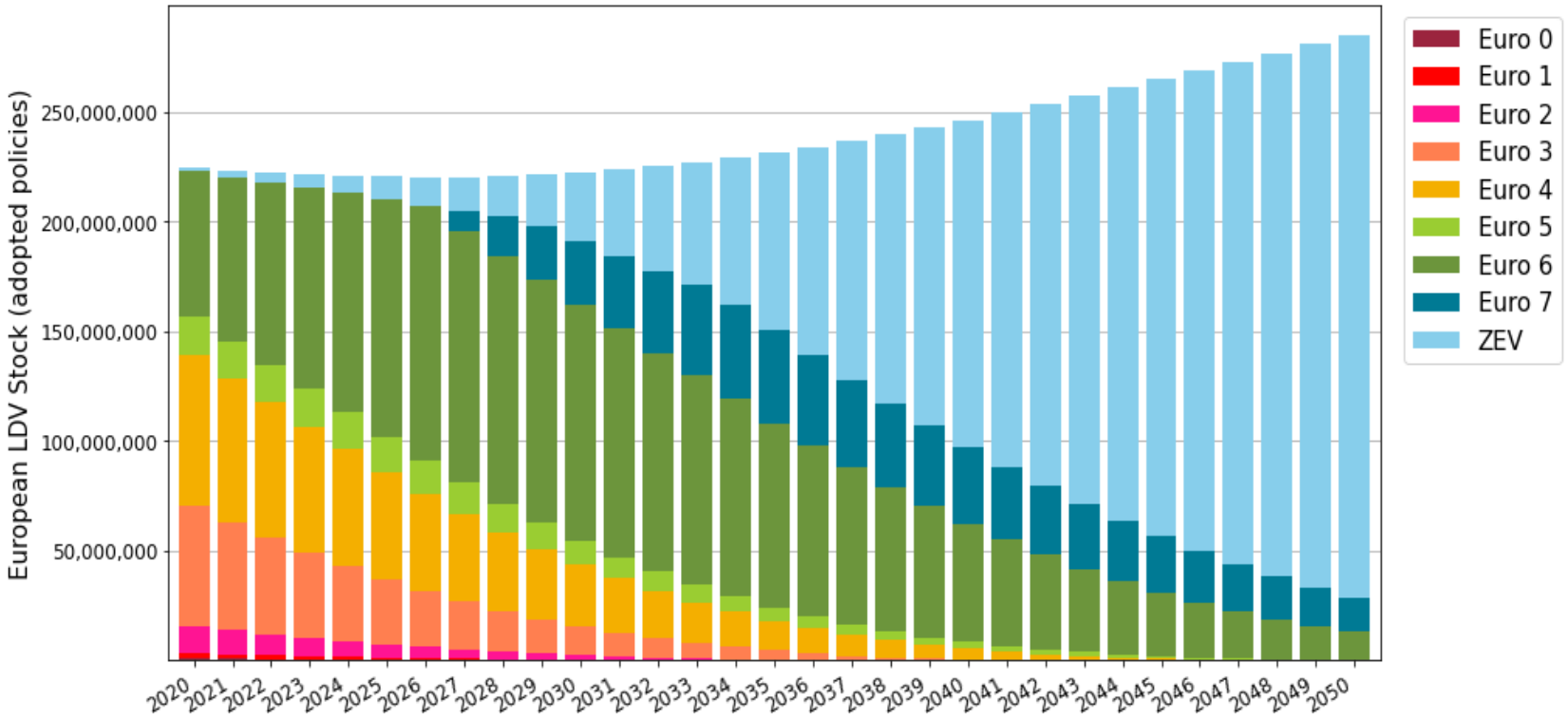
[2] International Council on Clean Transportation. ICCT's FATE Model Documentation (version 0.3), 2021. https://theicct.github.io/FATE-doc/versions/v0.3/

Stock Modelling – Light-duty vehicles

- The modelling follows projections for the uptake of zero-emission vehicles (ZEVs) driven by currently adopted policies
- Emission factors are used to account for the real-world emissions of vehicles from each Euro standard (conformity factors, low-power operation, cold start, etc.)

ZEVs – Light-duty vehicles:

Stringency of the revised CO_2 standards, which mandate a 100% reduction in CO_2 emissions for new vehicles in 2035, with an intermediate reduction target of 55% for passenger cars and 50% for vans in 2030 [3]



[3] European Commission. CO_2 emission performance standards for cars and vans, 2022. https://climate.ec.europa.eu/eu-action/european-green-deal/delivering-european-green-deal/co2-emission-performance-standards-cars-and-vans_en.

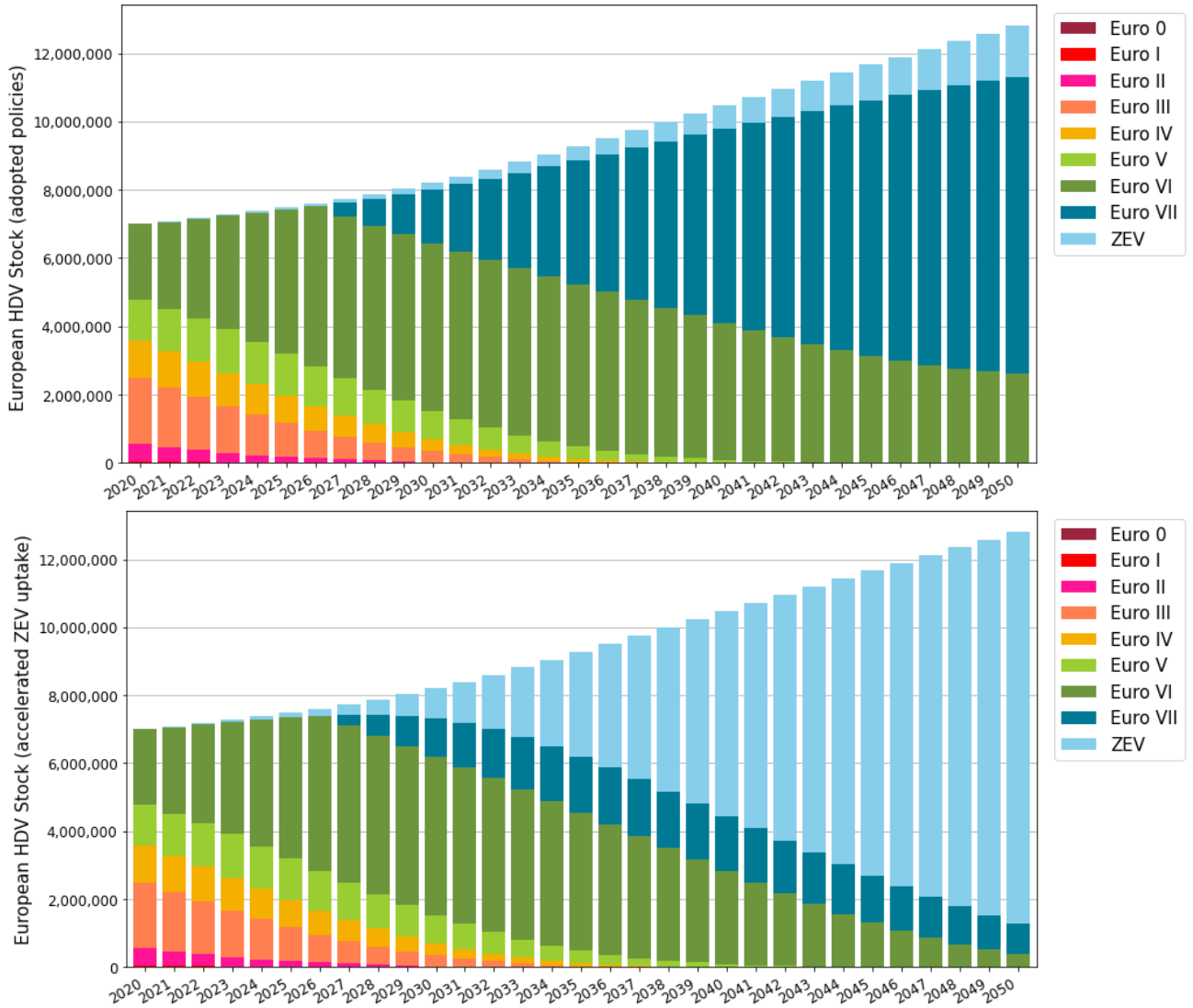
Stock Modelling – Heavy-duty vehicles

ZEVs – HDVs, adopted policies

Follows the sales levels mandated by the current HDV CO_2 standards, mandating CO_2 emissions reductions in new vehicles of 15% in 2025 and 30% in 2030 compared to a 2019-2020 baseline

ZEVs – HDVs, accelerated uptake

Follows the ambitions announced by European automobile manufacturers (projected ZEV stock share of 14% in 2030, 60% in 2040 and 90% in 2050), which closely aligns the sector with the EU Climate Law [4]



[4] Mulholland, Eamonn, Joshua Miller, Caleb Braun, Arijit Sen, Pierre-Louis Ragon, and Felipe Rodríguez. 2022. "The CO2 Standards Required for Trucks and Buses for Europe to Meet Its Climate Targets." Washington, D.C.: International Council on Clean Transportation. https://theicct.org/publication/hdv-co2standards-recs-mar22/.

Input data for tampering modelling

Tampering shares (%):
(share of vehicles being tampered with)

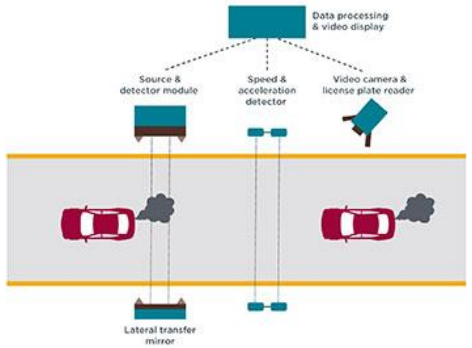
Vehicle Type	Scenario	NOx			PM		
		Euro 5/V	Euro 6/VI	Euro 7 /VII	Euro 5/V	Euro 6/VI	Euro 7/VII
LVS gasoline	Counterfactual	0	0	0	0	0	0
	Central Estimate	0	0	0	0	2.5	1.3
	Worst-Case	0	0	0	0	5	2.5
	Best-Case	0	0	0	0	1.3	0.7
LDVs diesel	Counterfactual	0	0	0	0	0	0
	Central Estimate	2.5	5	2.5	5	5	2.5
	Worst-Case	10	10	5	10	10	5
	Best-Case	2.5	2.5	1.3	2.5	2.5	1.3
HDVs	Counterfactual	0	0	0	0	0	0
	Central Estimate	8.6	6	3	8.6	6	3
	Worst-Case	18	13	6.5	10	10	5
	Best-Case	2.5	2.5	1.3	2.5	2.5	1.3

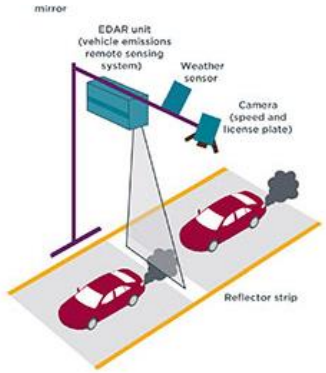
Tampering rates (-):
(ratio of tampered to non-tampered emissions)

Vehicle Type	Scenario	NOx			PM		
		Euro 5/V	Euro 6/VI	Euro 7 /VII	Euro 5/V	Euro 6/VI	Euro 7/VII
LDVs gasoline	Counterfactual	1	1	1	1	1	1
	Central Estimate	1	1	1	1	5	25
	Worst-Case	1	1	1	1	5	25
	Best-Case	1	1	1	1	2.5	25
LDVs diesel	Counterfactual	1	1	1	1	1	1
	Central Estimate	4	10	20	10	10	50
	Worst-Case	4	10	20	10	10	50
	Best-Case	4	10	20	10	10	50
HDVs	Counterfactual	1	1	1	1	1	1
	Central Estimate	4	10	20	4	10	50
	Worst-Case	4	20	40	4	10	50
	Best-Case	4	10	20	4	10	50

Based on roadside inspection campaigns using

- Remote sensing
- Plume chasing






Schematic of plume chasing remote emission sensing device.

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Modelling scenarios

- **Scenario 1: Counterfactual scenario**

This scenario assumes no tampering occurred historically or will occur in the future. As a baseline, it illustrates the maximum theoretical benefits of anti-tampering regulation.

- **Scenario 2: Central Estimate scenario**

This scenario reflects our best estimate for the actual tampering shares and tampering rates based on evidence from different roadside inspections and remote sensing emission measurement campaigns in Europe.

- **Scenario 3: Worst-Case scenario**

This scenario models the highest values of tampering shares and tampering rates from the available data, which reflects a worst-case scenario and provides an upper bound for the real-world impacts of tampering.

- **Scenario 4: Best-Case scenario**

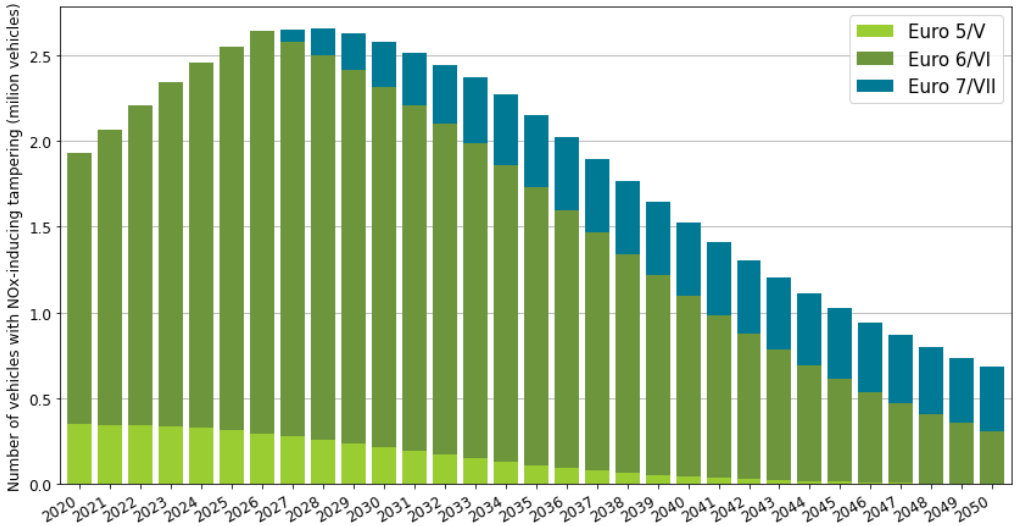
This scenario models the lowest values of tampering shares and tampering rates from the available data, which provides a lower bound for the real-world impacts of tampering.

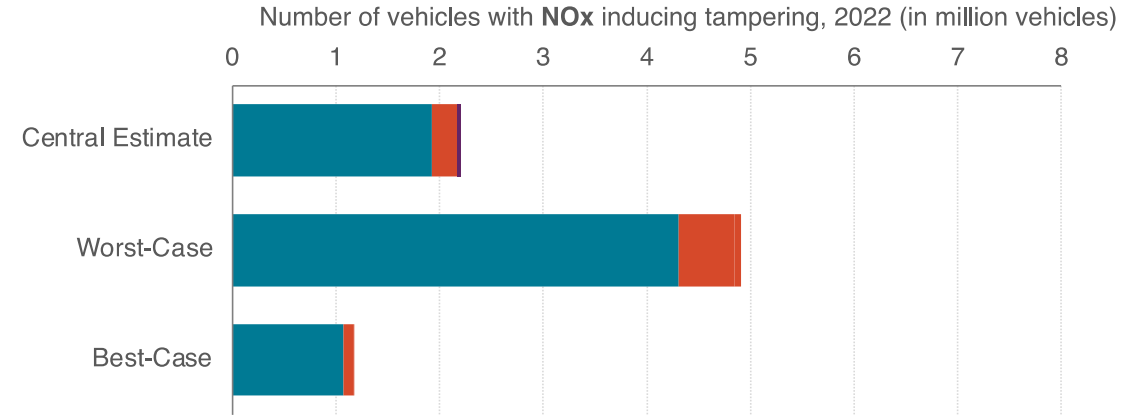
Tampering affects between 4 and 6 million vehicles in 2022

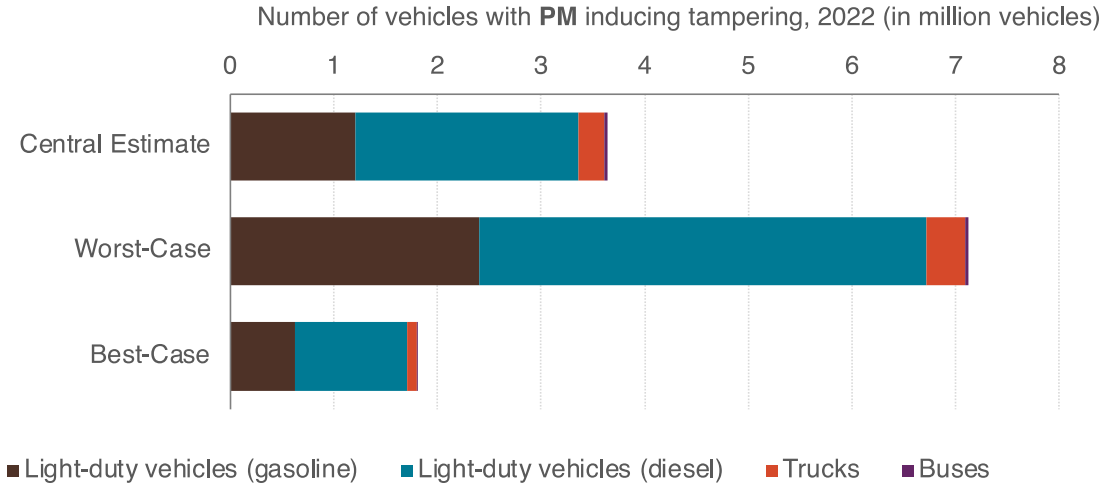
- Under the Central Estimate scenario, between 4 and 6 million vehicles are affected by tampering. This number goes up to 12 million vehicles in the Worst-Case scenario

- Euro 6/VI vehicles represent the majority of tampered vehicles through 2050

Breakdown by emissions control for NOx-inducing tampering (Central Estimate)

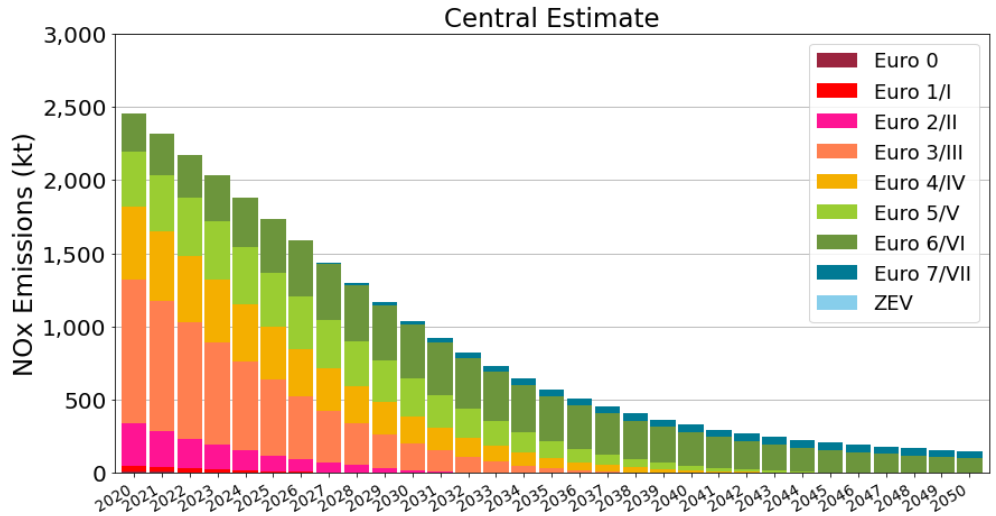


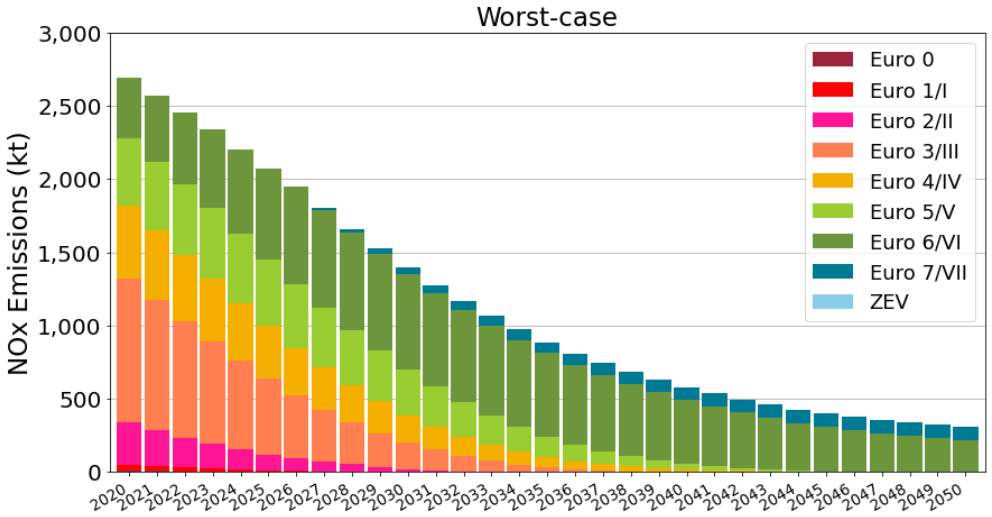


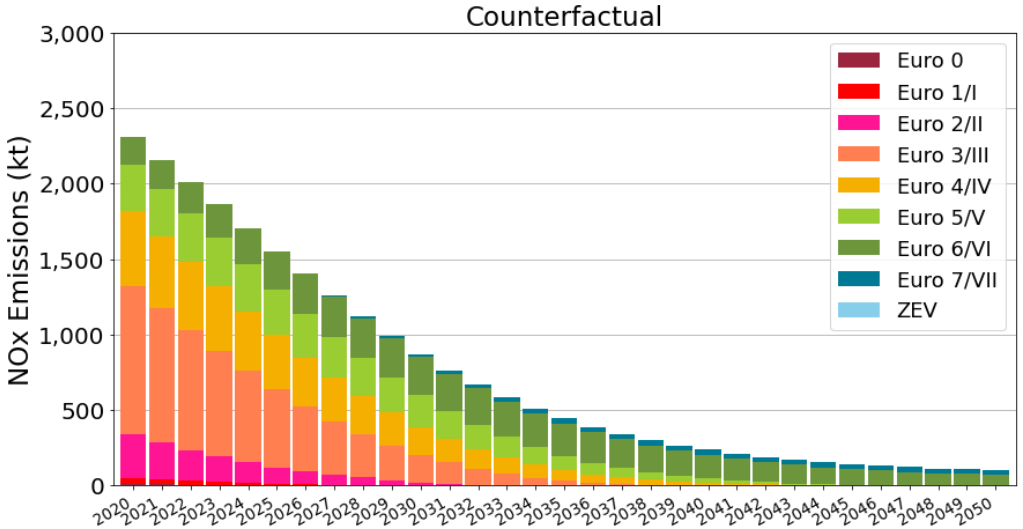


Measures to address tampering could help avoid up to 12.2 megatonnes of NOx emissions (2022-2050), looking at the Worst-Case scenario

- Under the Central Estimate scenario, NOx emissions reduce 52% by 2030, 84% by 2040, and 93% by 2050
- These numbers reduce to 43% by 2030, 76% by 2040, and 87% by 2050 for the Worst-Case scenario

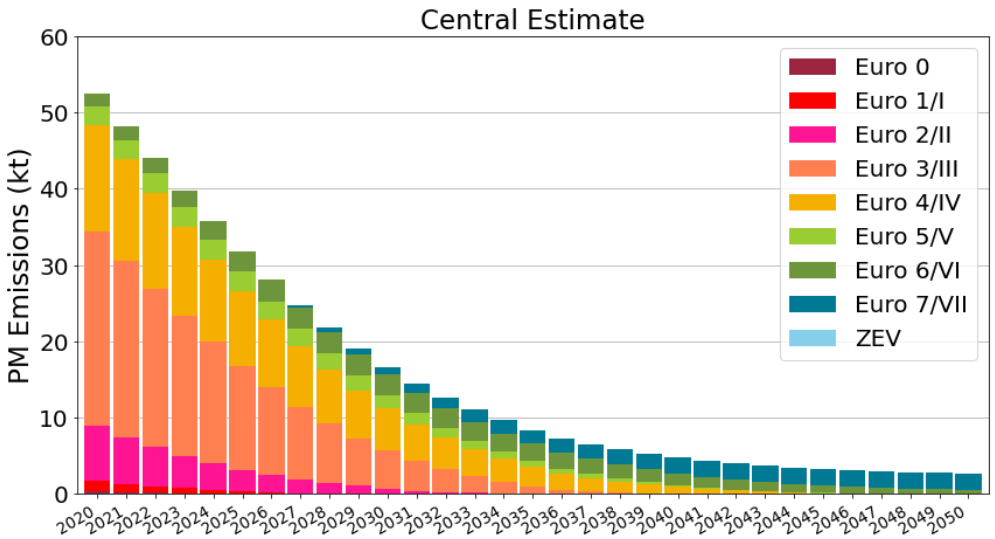


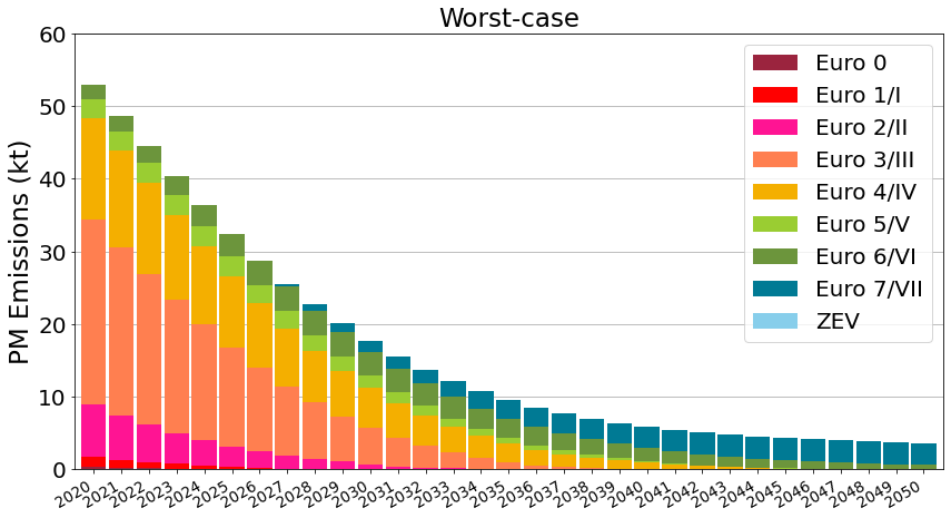


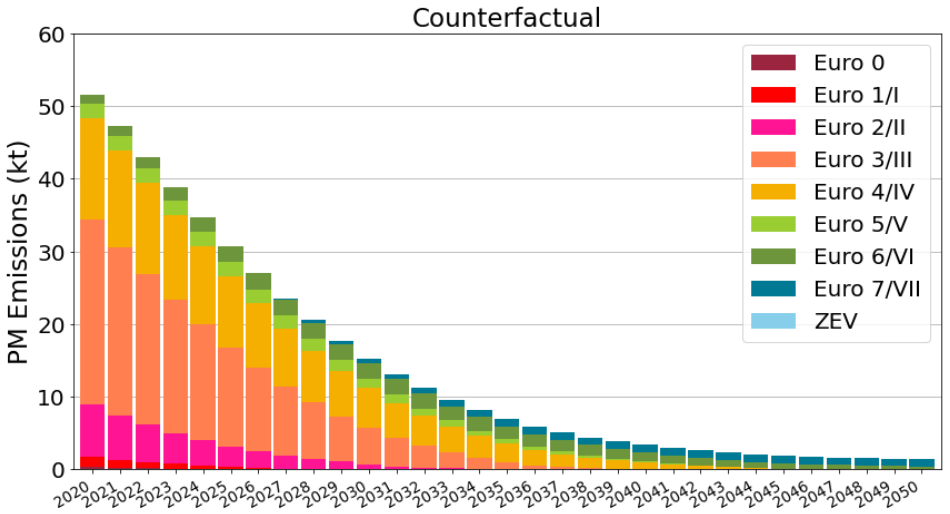


Measures to address tampering could help avoid up to 69.6 kilotonnes of PM emissions 2022 - 2050, looking at the Worst-Case scenario

- Under the Central Estimate scenario, PM emissions reduce 62% by 2030, 89% by 2040, and 94% by 2050
- These numbers reduce to 60% by 2030, 86% by 2040, and 91% by 2050 for the Worst-Case scenario



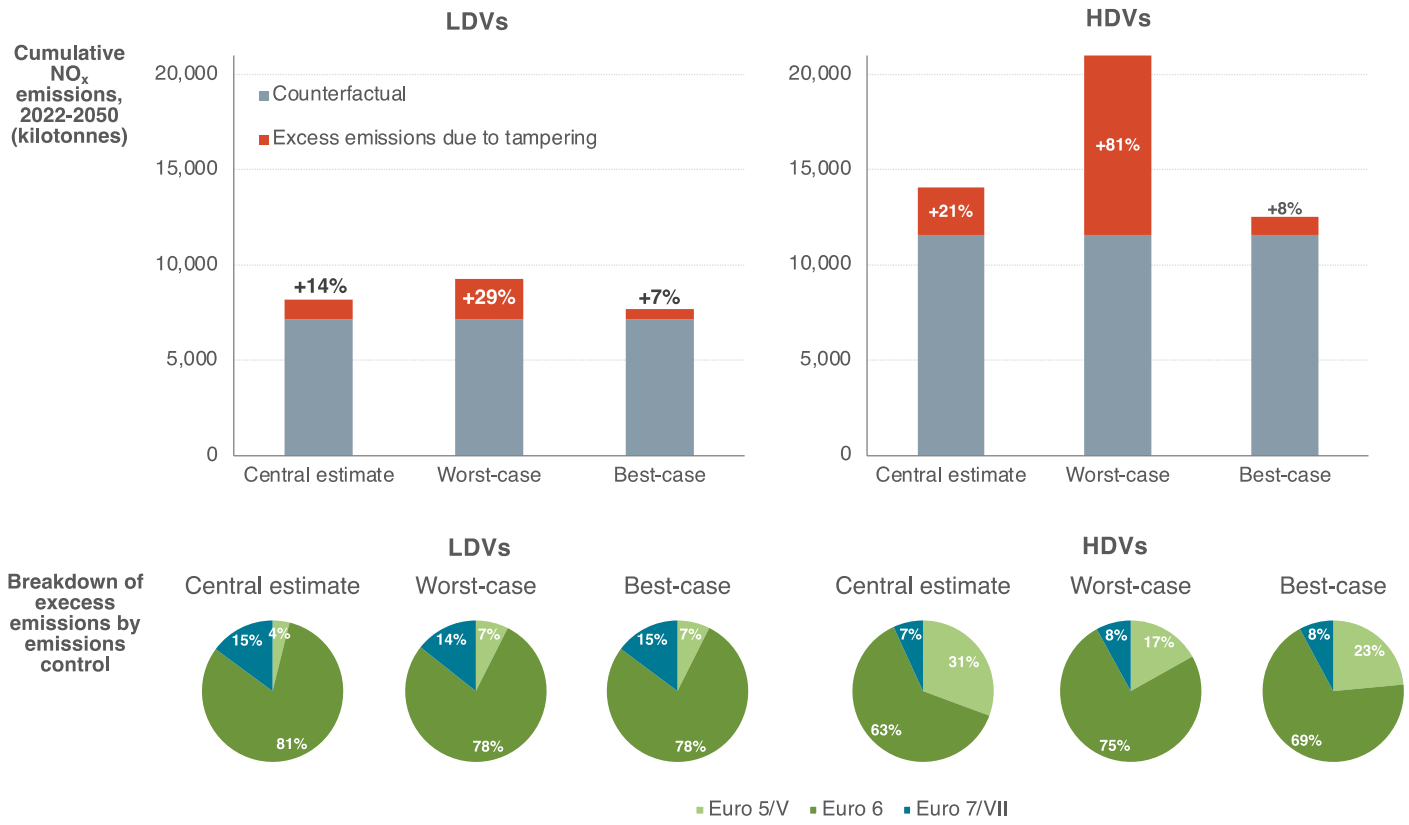




Under Central Estimate scenario, up to 81% of excess NOx emissions come from Euro 6 vehicles

- Tampering is estimated to increase NOx emissions in LDVs between 7% and 29% over the 2022-2050 period depending on the modelling scenario, and 14% under the Central Estimate scenario.

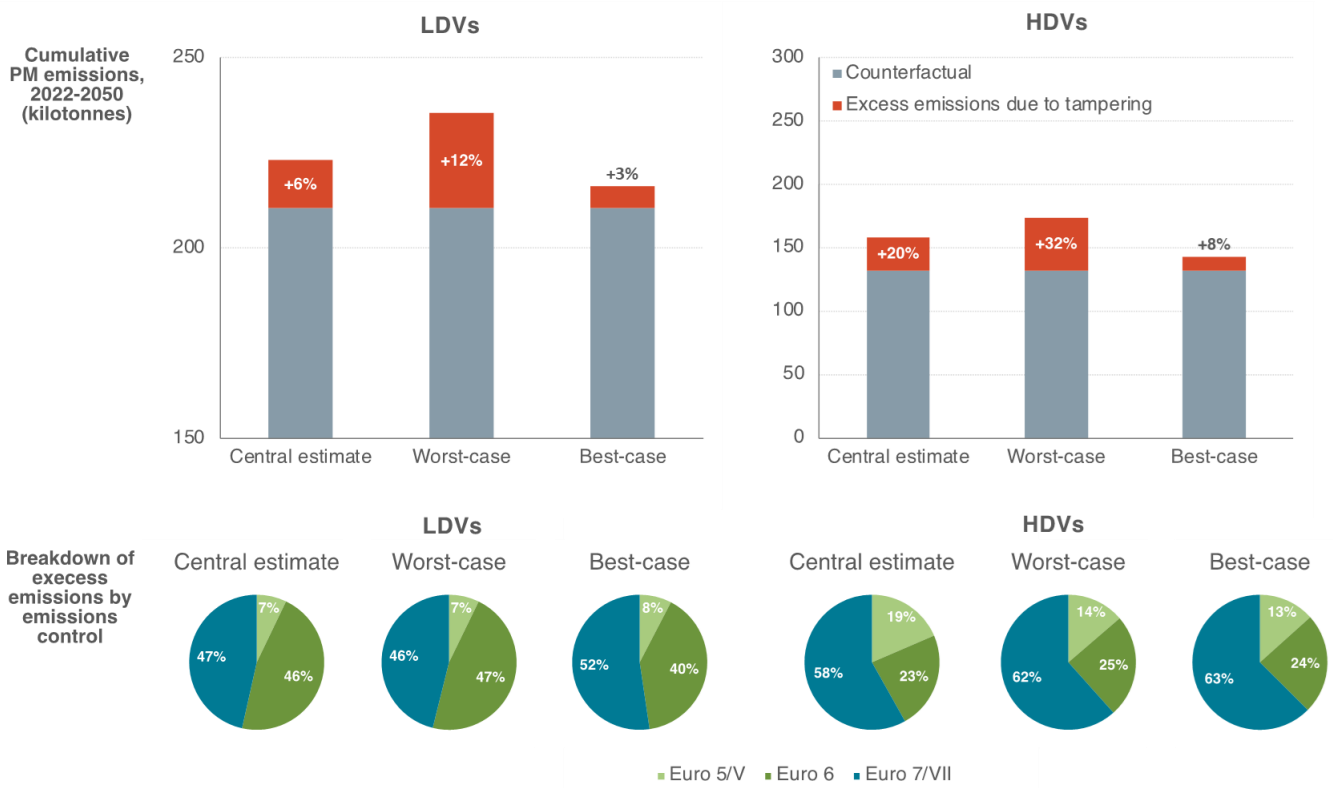
- For HDVs, tampering is projected to increase NOx emissions between 8% and 81% over the 2022-2050 period, and 21% under the Central Estimate scenario. Excess emissions in that scenario originate at 63% from Euro VI vehicles, 31% from Euro V vehicles and 7% from Euro VII vehicles



In the Central Estimate scenario, excess PM emissions originate mostly from Euro 7 and Euro 6 vehicles

- For light-duty vehicles, tampering is estimated to increase PM emissions by 6% over the 2022-2050 period under the Central Estimate, and up to 12% in the Worst-Case scenario.

- PM emissions from heavy-duty vehicles are projected to increase 20% due to tampering in the Central Estimate scenario, and up to 32% in the Worst-Case scenario. Most of the excess emissions come from Euro VII vehicles (58% under the Central Estimate scenario), followed by Euro VI (23%) and Euro V (19%) vehicles.

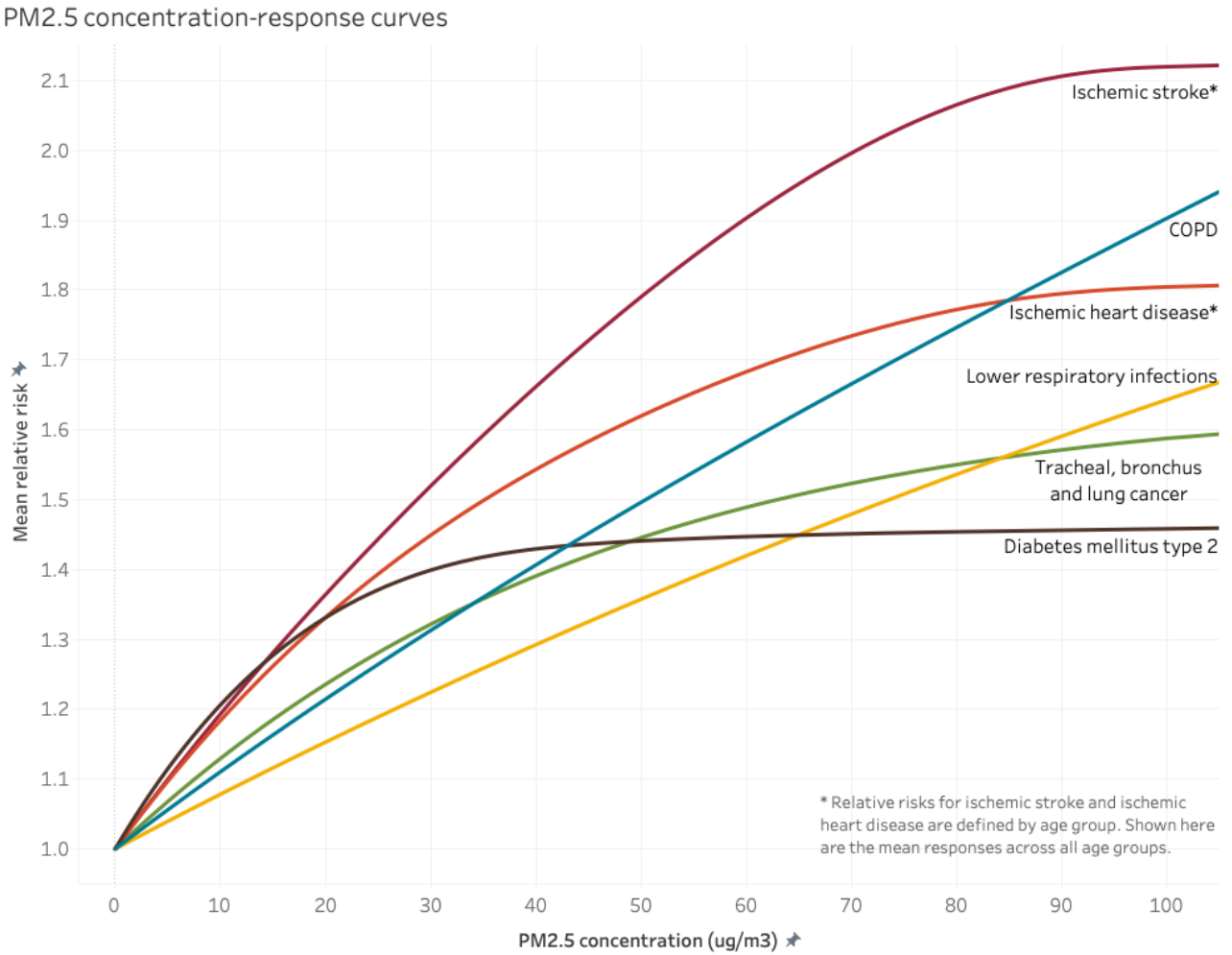


Excess emissions from tampering result ischemic heart disease, chronic obstructive pulmonary disease, lower respiratory infection, lung cancer, and diabetes mellitus type 2

- Excess emissions from tampering result in higher ambient concentrations of harmful pollutants such as $PM_{2.5}$ and O_3 and consequently can lead to several respiratory and heart-related diseases, which can eventually lead to air-quality related premature deaths.

- FATE calculates the effects of air pollutant emissions on the ambient concentration of particulate matter ($PM_{2.5}$) and ozone (O_3) pollutants, and the associated health impacts. It uses coefficients derived from the GEOS-chem model.

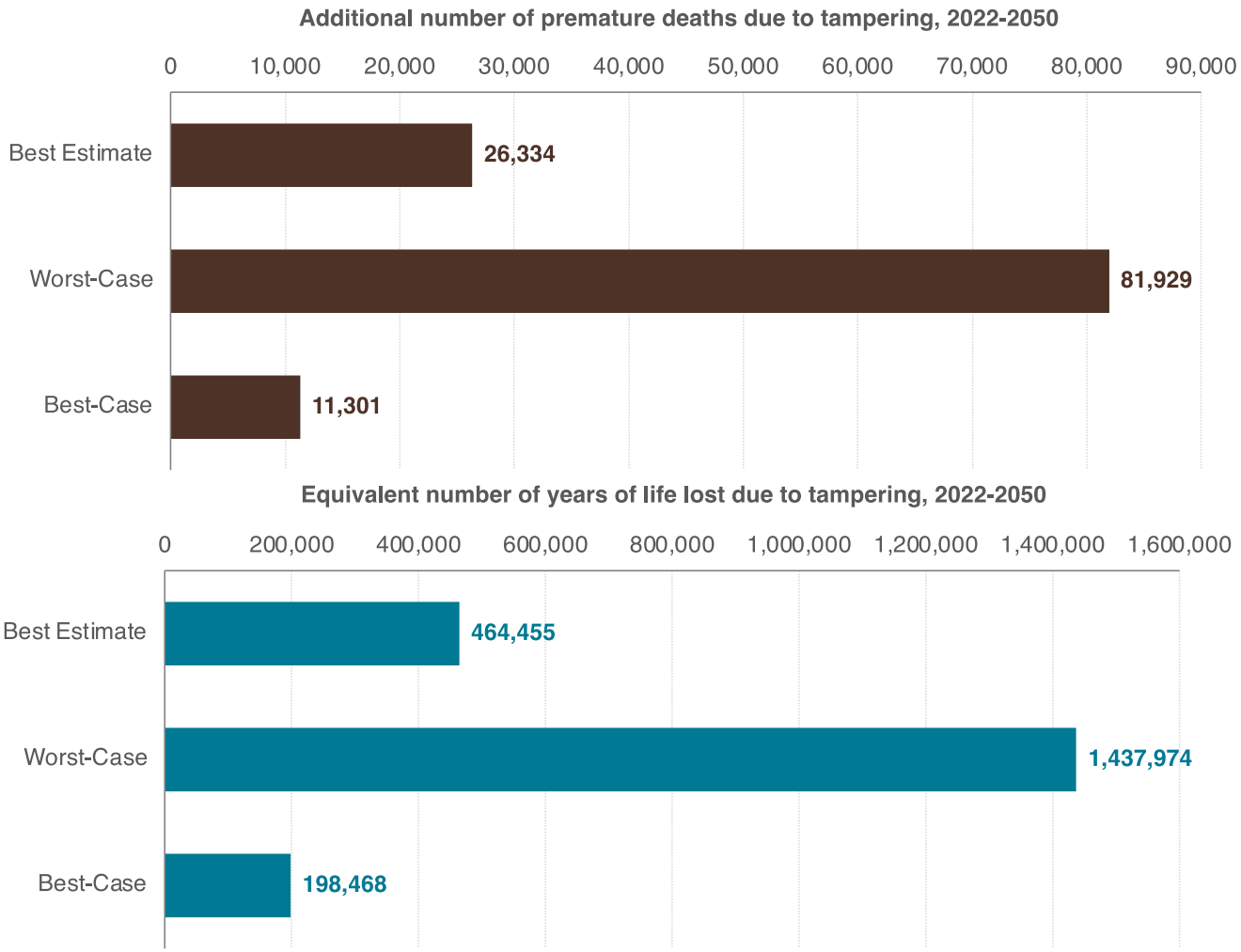
- The two key metrics used to assess health impacts are the number of premature deaths, and the number of years of life lost due to premature deaths



International Council on Clean Transportation. ICCT's FATE Model Documentation (version 0.3), 2021. https://theicct.github.io/FATE-doc/versions/v0.3/

Tampering can cause up to 82,000 additional premature deaths in Europe under Worst-Case scenario

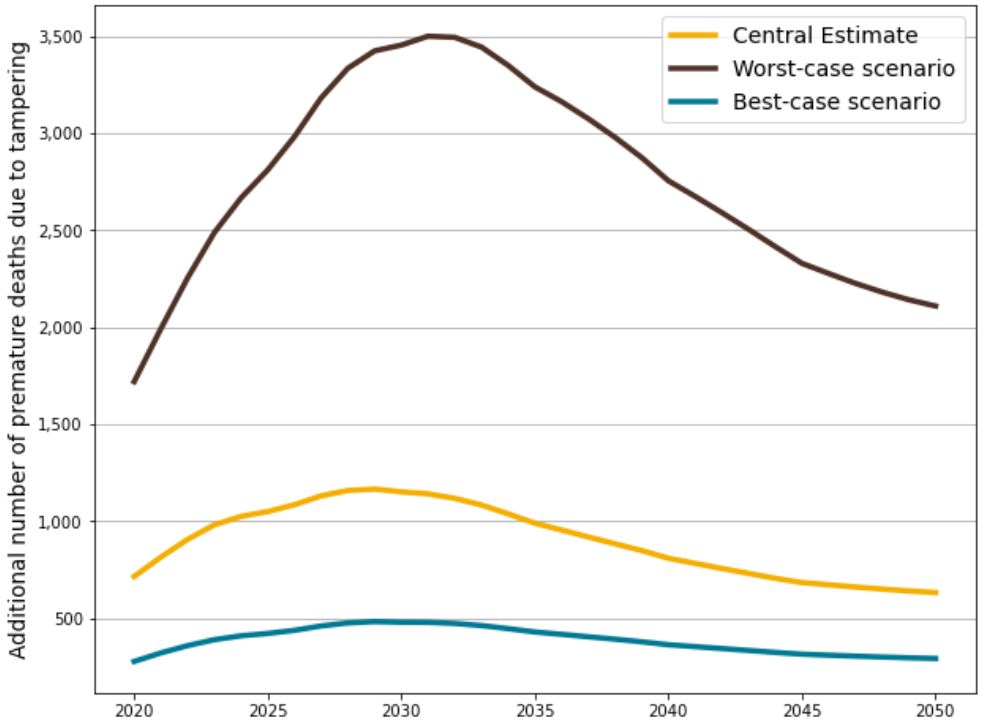
- Under the Central Estimate scenario, tampering leads to around 26,000 additional premature deaths, which equates to 464,000 years of life lost compared to a case of no tampering. .
- These number increase to 82,000 premature deaths which equates to 1,438,000 years of life lost under the Worst-Case scenario
- In the Best-Case scenario additional number of premature deaths and years of life lost decrease to 11,300 and 198,000 respectively.



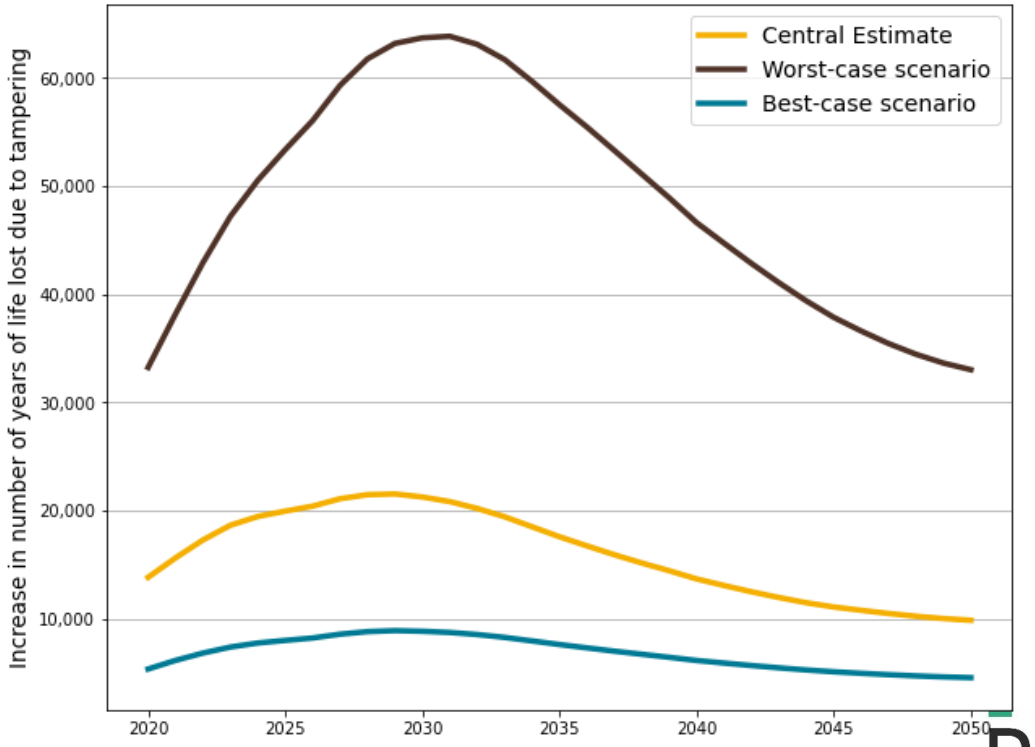
Health burdens of tampered vehicles in the 2022-2030

- In the 2022-2030 period, the health burden increases much faster under the Worst-Case scenario than under the other two scenarios, highlighting the interest of limiting the extent of tampering to a minimum.
- After 2028, the health impacts of tampering are expected to reduce as excess emissions from tampering reduces, due to both the implementation of Euro 7/VII standards and a higher share of zero-emission vehicles.

Additional number of premature deaths (2022-2050)



Increase in number of years of lost life (2022-2050)



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Q & A

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