Ammonia Emissions from Vehicle Emissions Measurements

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Riaghaltas na h-Alba

RICARDO

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Scottish Air Quality Seminar

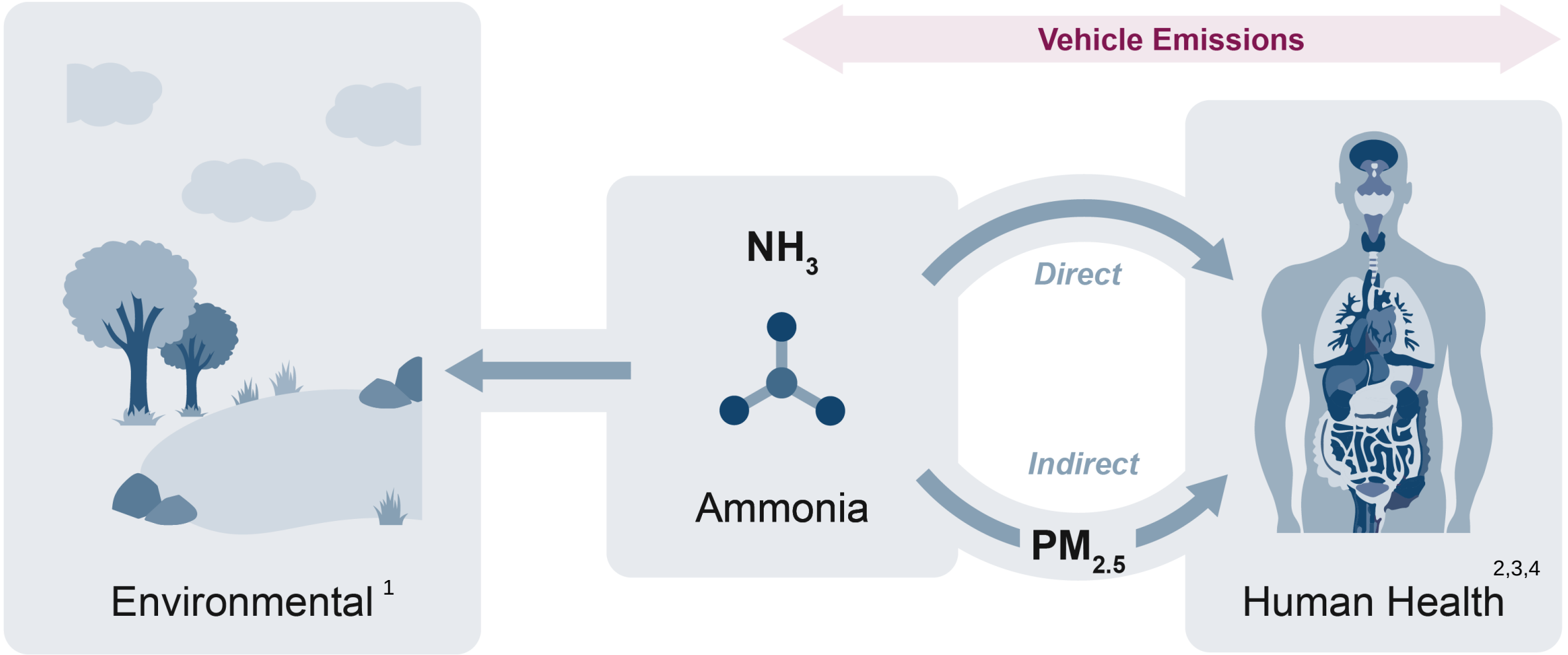
26th March 2025

Presentation Outline

1.

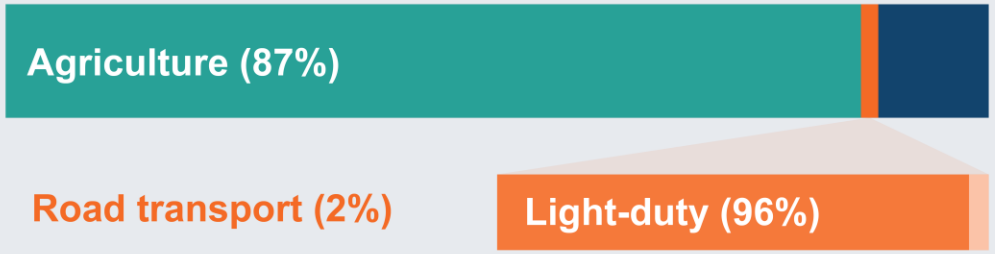
Introduction

Ammonia Emissions: Why are they important?



Ammonia Emissions: Where do they come from?

Total **UK** 2022 NH_3 emissions: **260 kT** [5]

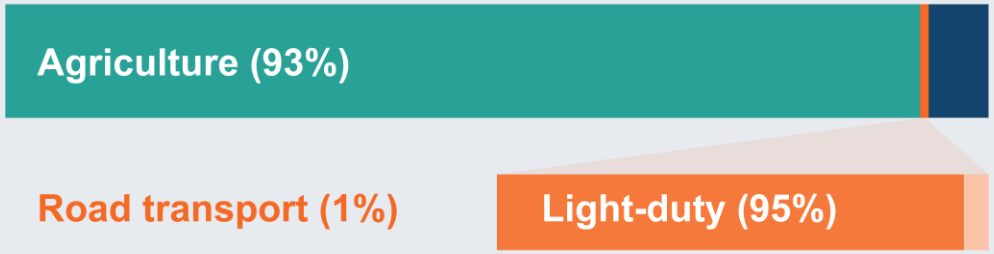


[6]

Land area:
240,000 km²

Population:
67.1 million

Total **Scotland** 2022 NH_3 emissions: **31 kT** [5]



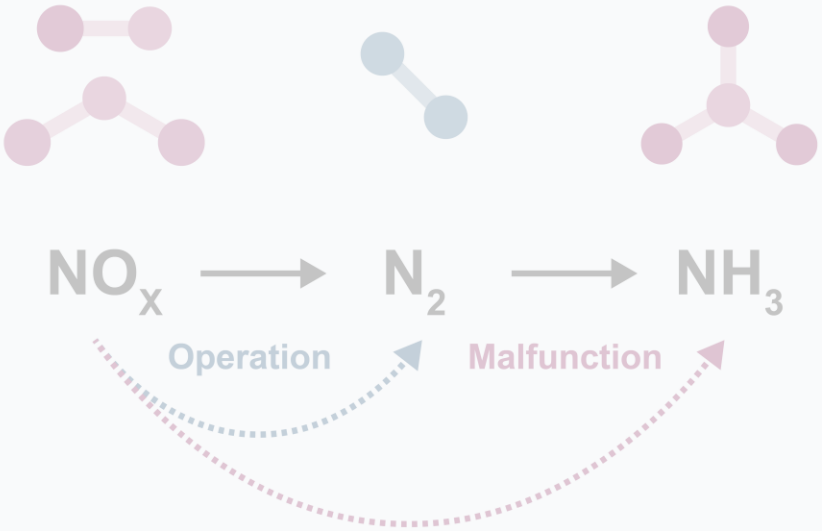
[7]

Land area:
77,900 km²

Population:
5.4 million

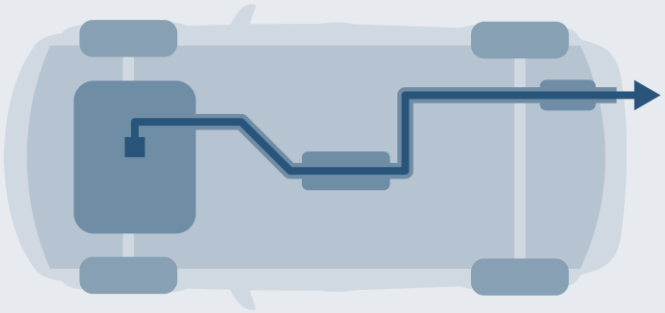
Vehicular Sources: Catalysis

NH_3 is not produced during combustion, it is a product of **NO_x reduction catalysis** [8]



Gasoline

Three-way catalyst (TWC)



Light-duty vehicles **1980**

(passenger cars)

Diesel

Selective catalytic reduction (SCR)

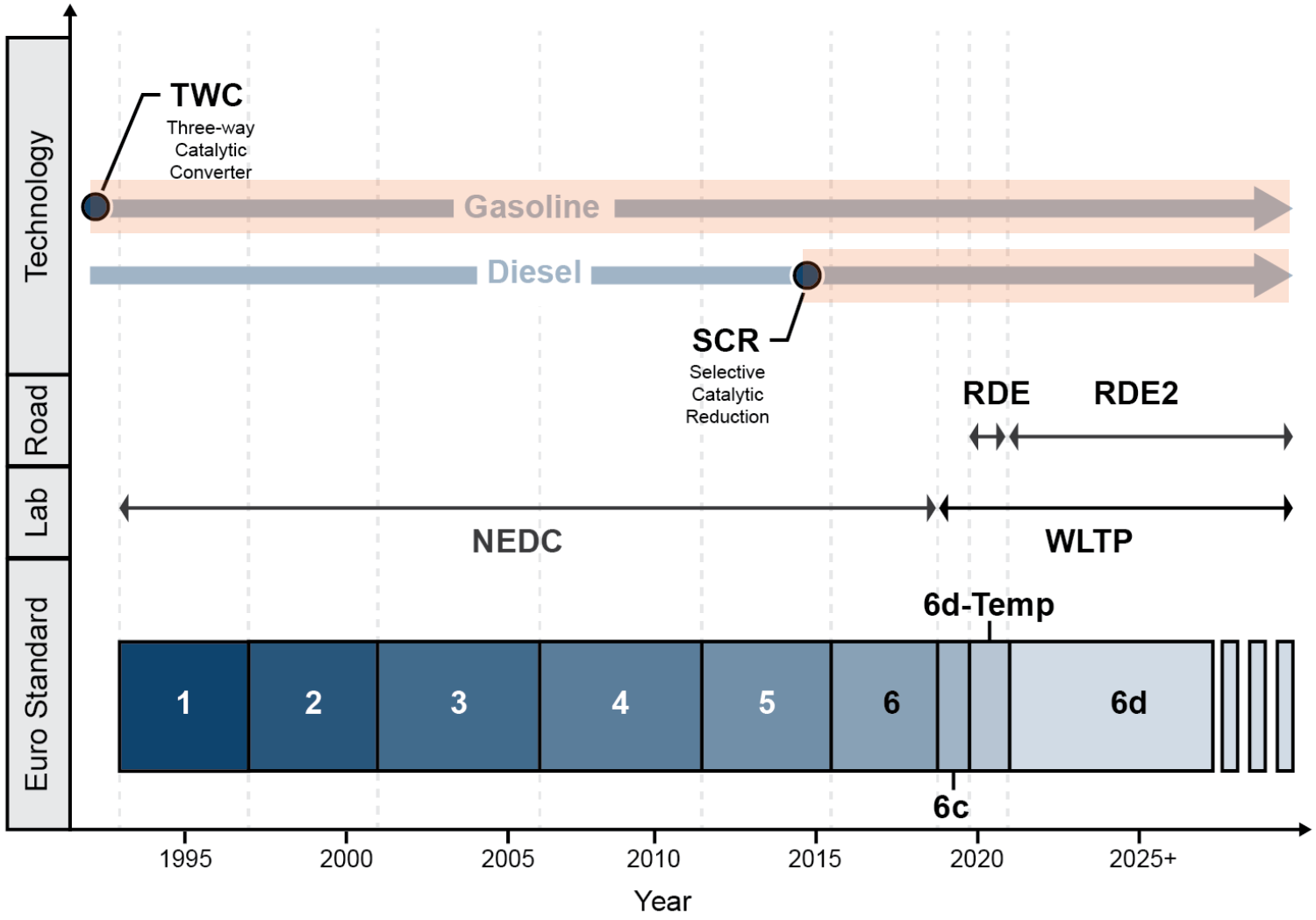
Heavy-duty vehicles **2010**

Light-duty vehicles **2015**

Vehicular Sources: Regulation

Euro Emission Standards [5,9]

- Increasingly stringent vehicle testing (laboratory and real-driving emissions RDE)
- Separate standards for light-duty (shown right) and heavy-duty vehicles
- Ammonia is currently **unregulated** for light-duty vehicles
- Light-duty vehicles account for 96% of vehicular NH_3 in the UK (95% in Scotland)



2.

Measurement Techniques

Vehicle Emissions Measurements

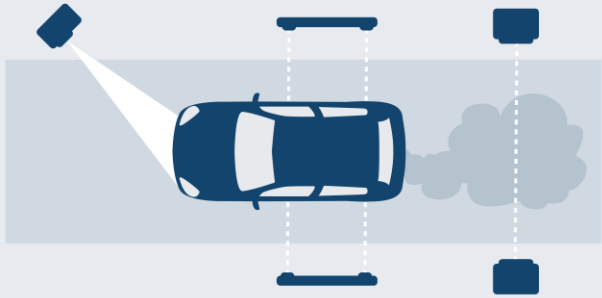
Control

Representativity

Laboratory Testing

PEMS Testing

(Small Sample)

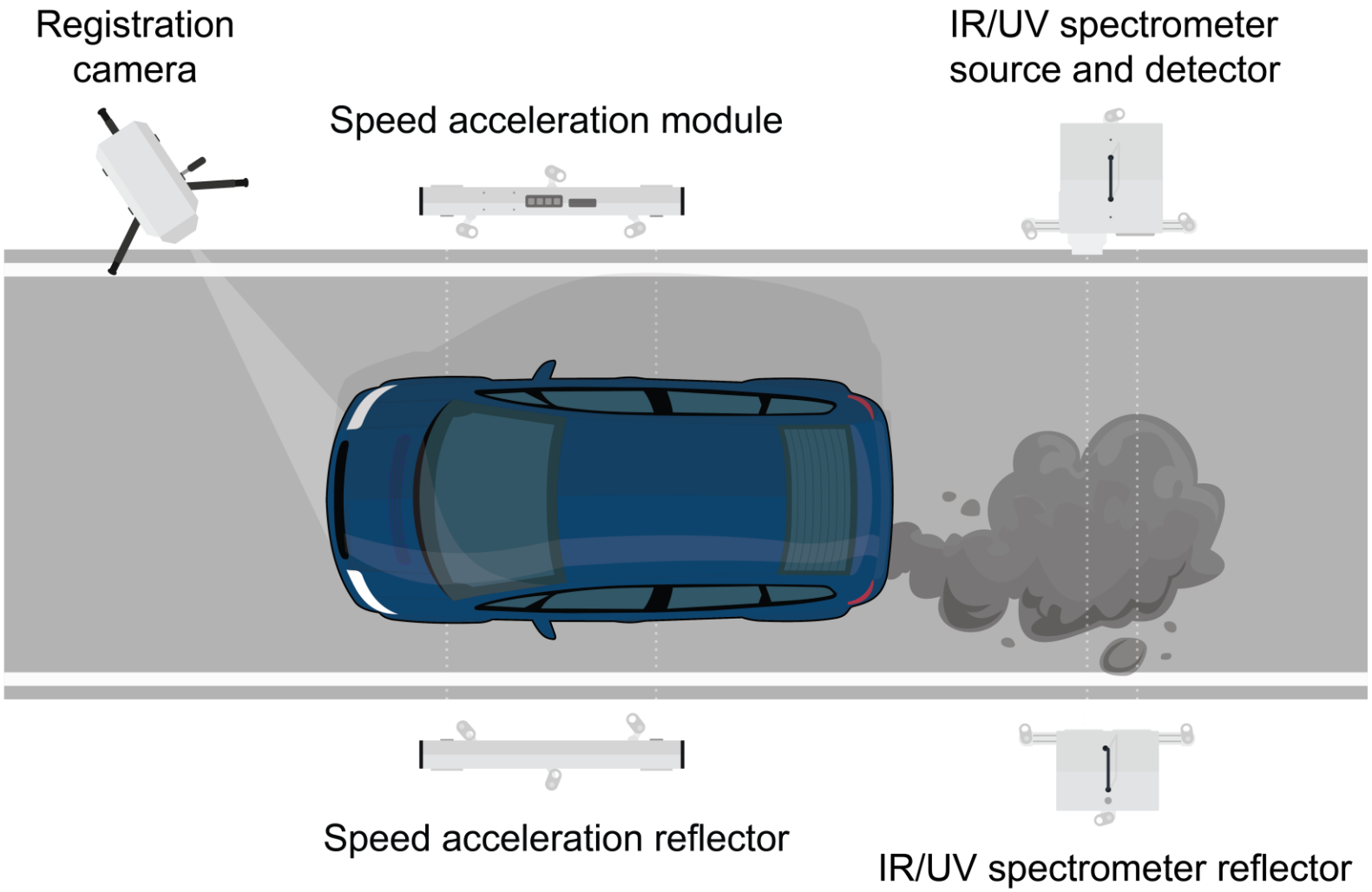


Roadside Testing

(Large Sample)

Real-world Vehicle Emissions

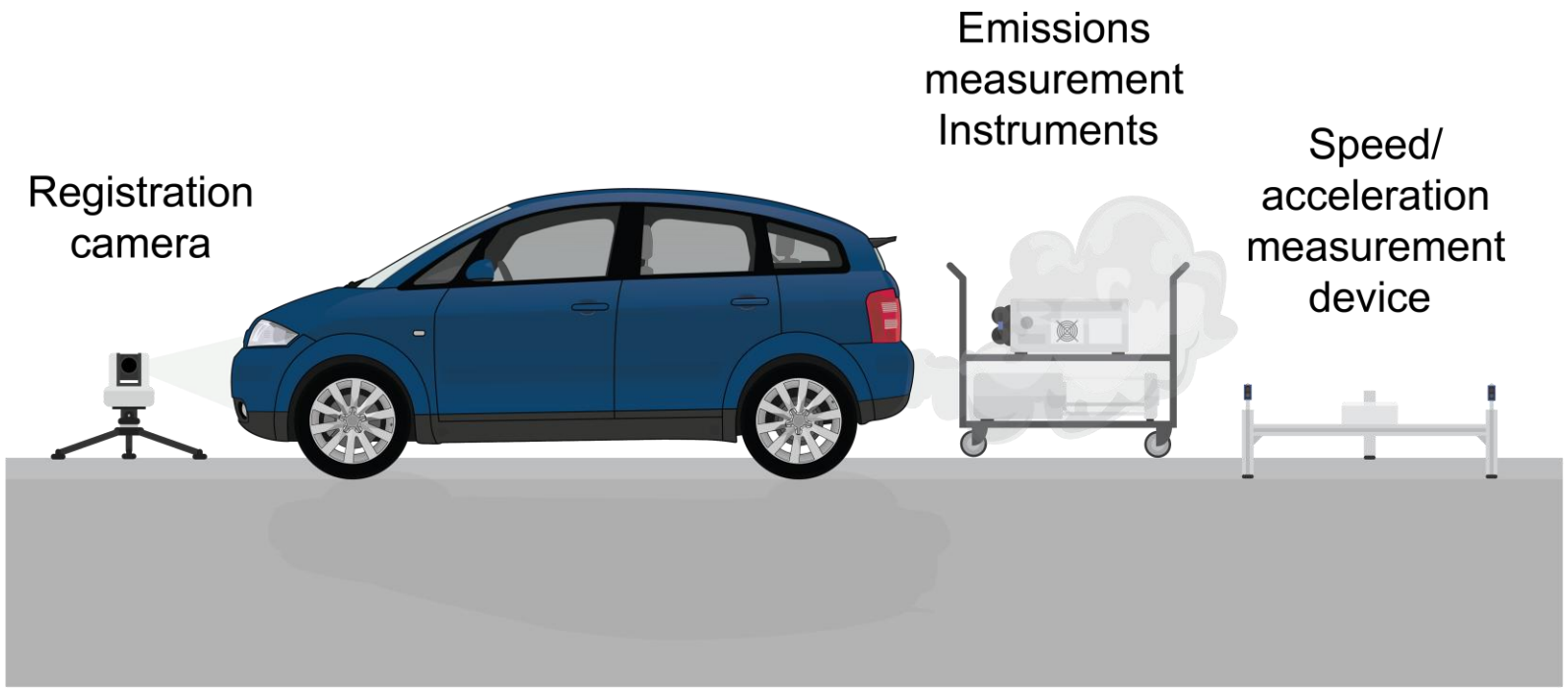
Remote Sensing



Technique Overview

- Cross-road IR and UV snapshot spectroscopy
  "Emissions camera"
- Full commercial system
- > 600,000 UK vehicle measurements available made 2012 – 2022
- Aggregate measurements to calculate NH_3 emission factors (g kg^{-1} / g km^{-1})

Point Sampling



Technique Overview

- Continuous fast-response emissions measurements
  "Emissions video camera"
- New and developing technique
- Robust linear regression to calculate NH_3 emission factors (g kg^{-1})
- More sensitive instruments

3.

Research Results

Literature Summary

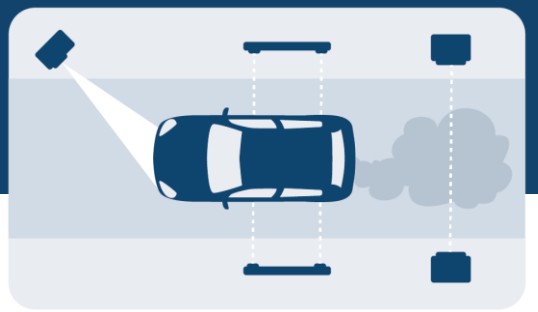
Vehicular ammonia is dominated by **Gasoline cars** [10]

Vehicular ammonia decreasing with new **catalyst technology** [10]

Vehicular ammonia **under-represented** in national inventories [11]

Vehicular ammonia contributes towards **$PM_{2.5}$** formation [2,3,4]

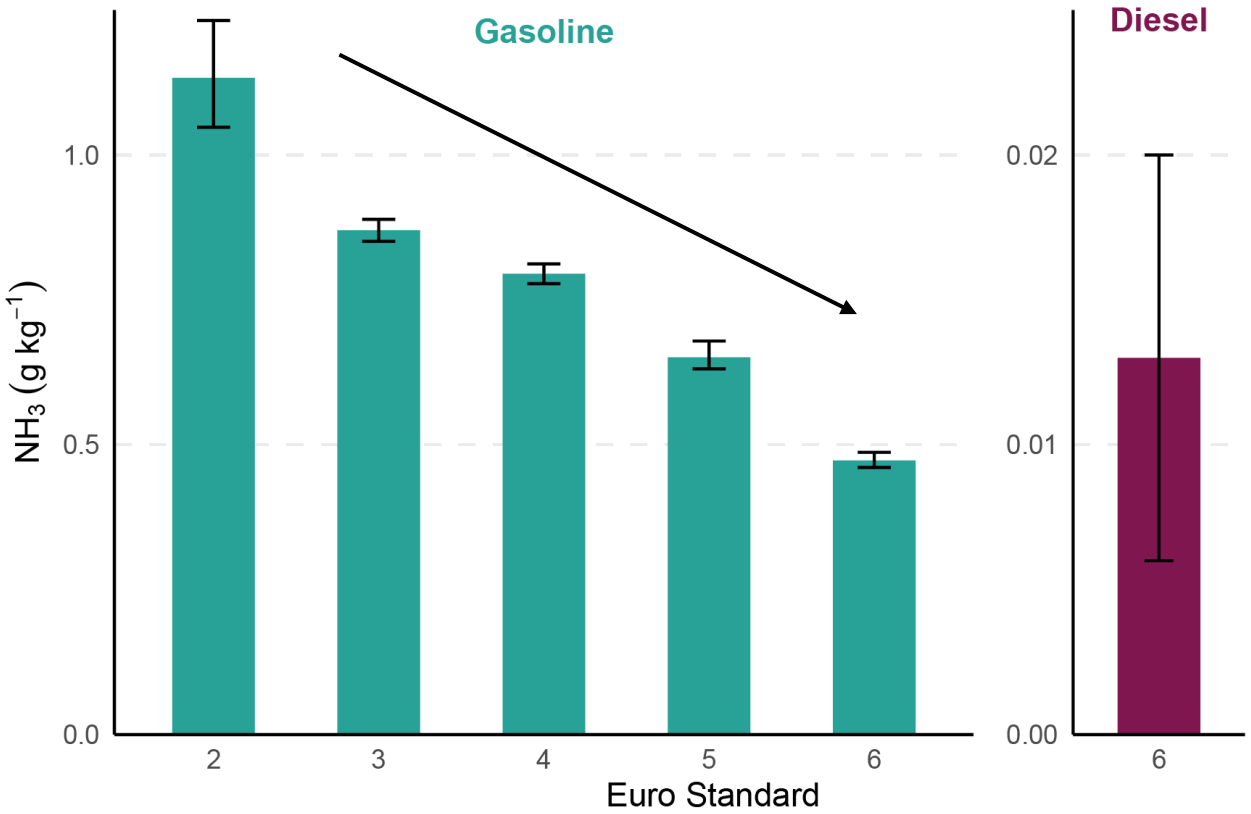
Remote Sensing I



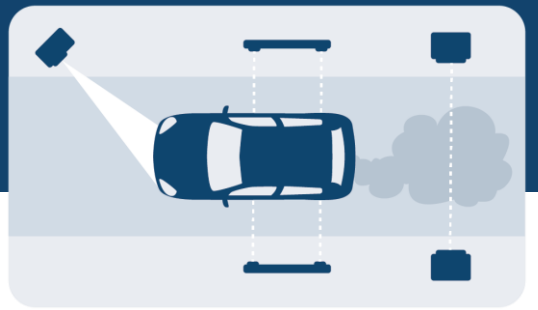
Underestimated Ammonia Emissions from Road Vehicles, N. J. Farren, J. Davison et al., *Environ. Sci. Tech.*, **2020**

Results and Insight

- NH_3 emission factors reported for passenger cars (shown right)
- UK passenger car NH_3 emissions **2.6 x higher** than reported (NAEI)
- Increases to **17 x higher** in urban areas



Remote Sensing I

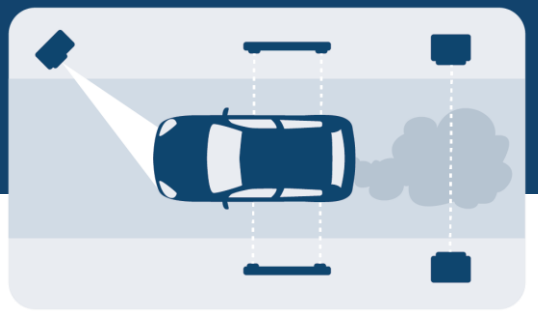


Underestimated Ammonia Emissions from Road Vehicles, N. J. Farren, J. Davison et al., *Environ. Sci. Tech.*, **2020**

Vehicular ammonia emissions dominated by **gasoline cars**

Vehicular ammonia emissions **under-represented** in UK NAEI

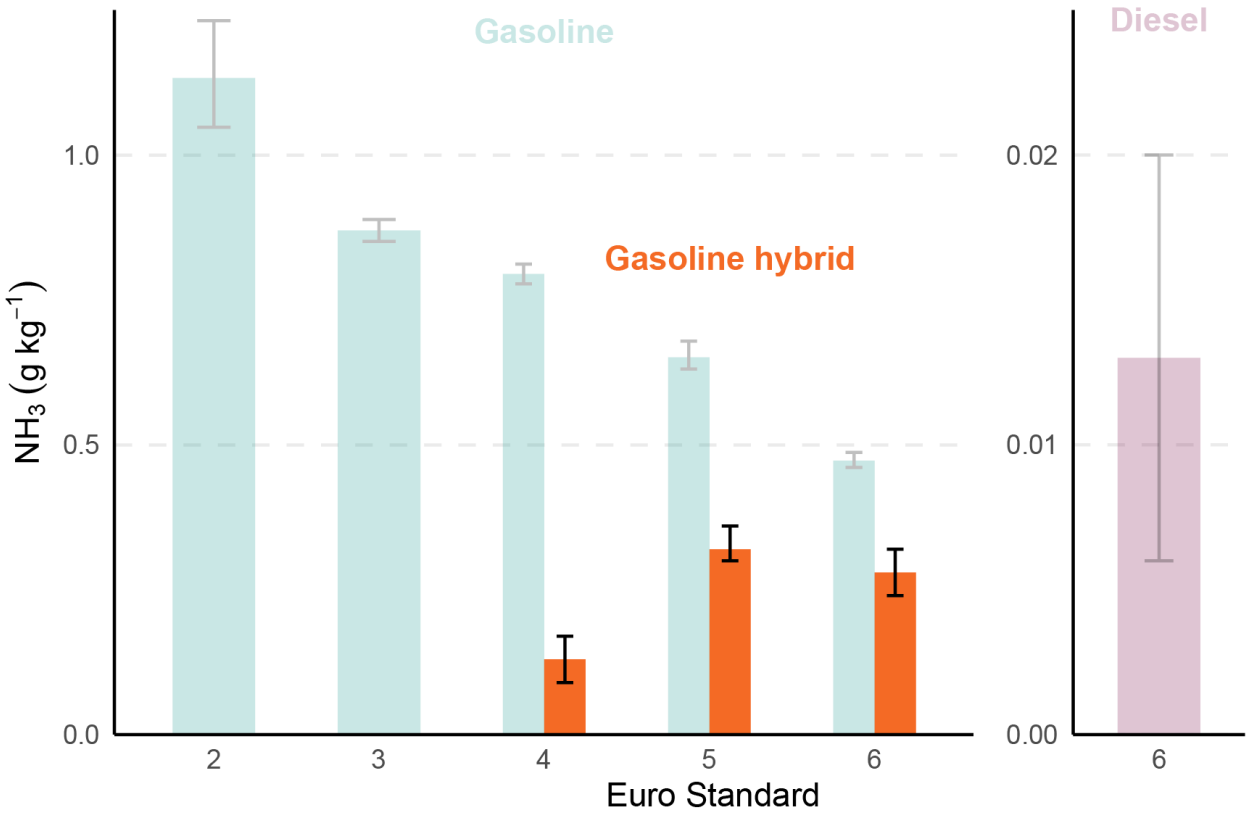
Remote Sensing II



Characterisation of ammonia emissions from gasoline and gasoline hybrid passenger cars, N. J. Farren, J. Davison et al., Atmos. *Environ. X,* **2021**

Results and Insight

- NH_3 emission factors reported for hybrid cars (shown right)



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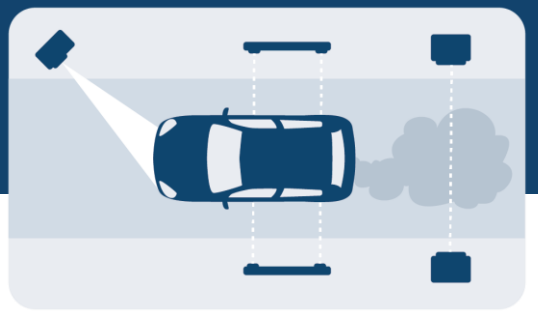

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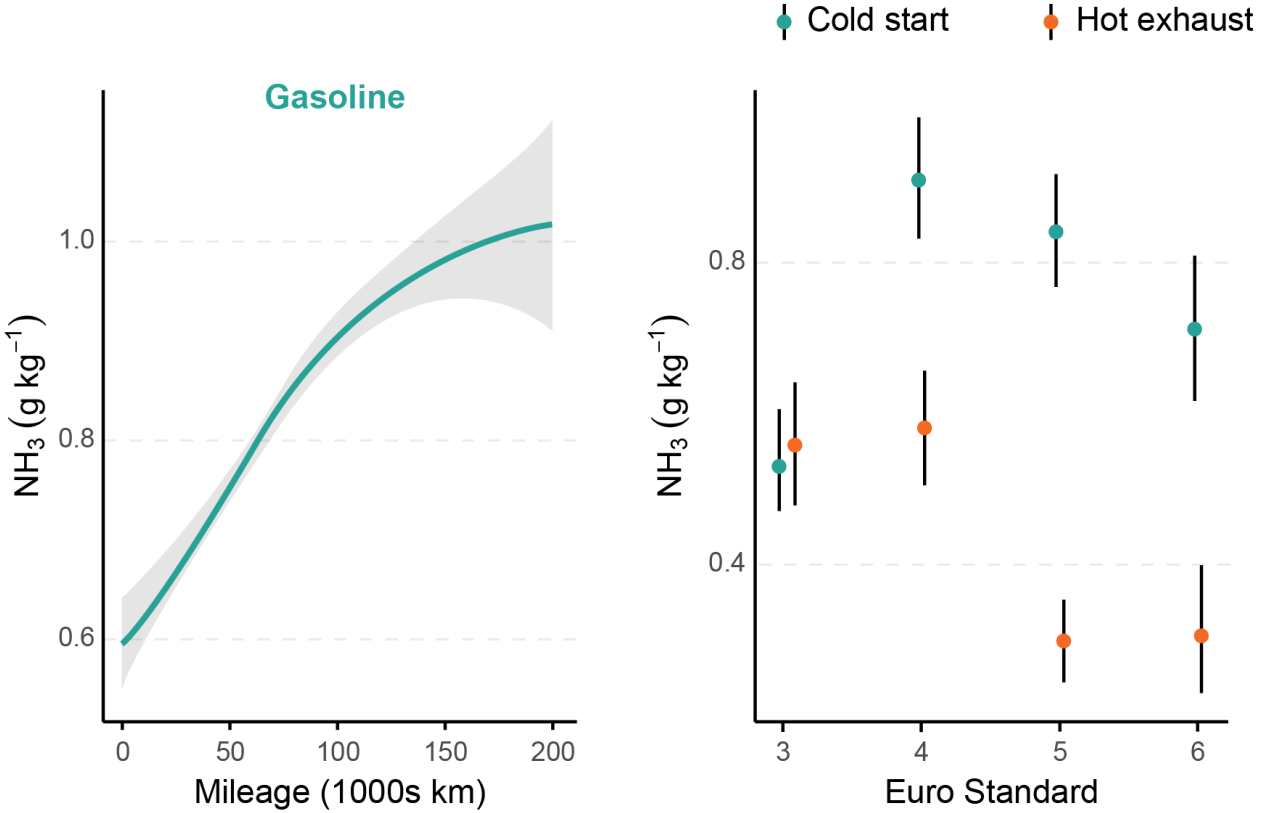
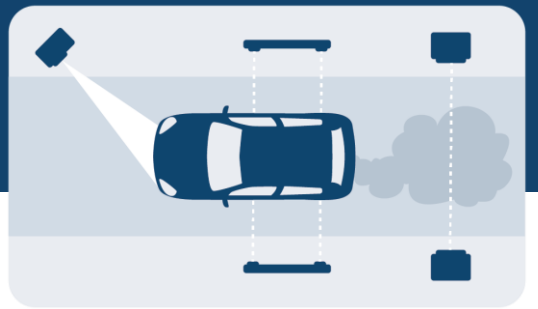
Results and Insight

- NH_3 emission factors reported for hybrid cars (shown right)
- Increasing NH_3 emissions associated with increasing vehicle mileage
- Increasing NH_3 emissions associated with cold start



Remote Sensing II

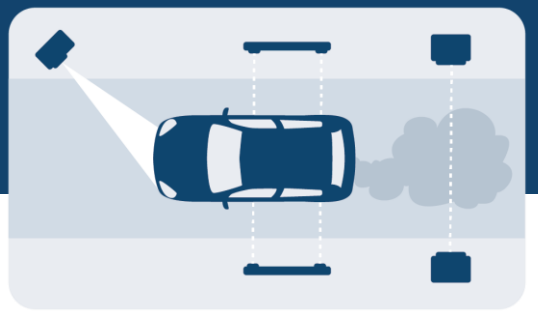


Characterisation of ammonia emissions from gasoline and gasoline hybrid passenger cars, N. J. Farren, J. Davison et al., Atmos. *Environ. X,* **2021**

Gasoline hybrid vehicles are an important ammonia source

Ammonia emissions increase with **mileage** (age) and **cold start**

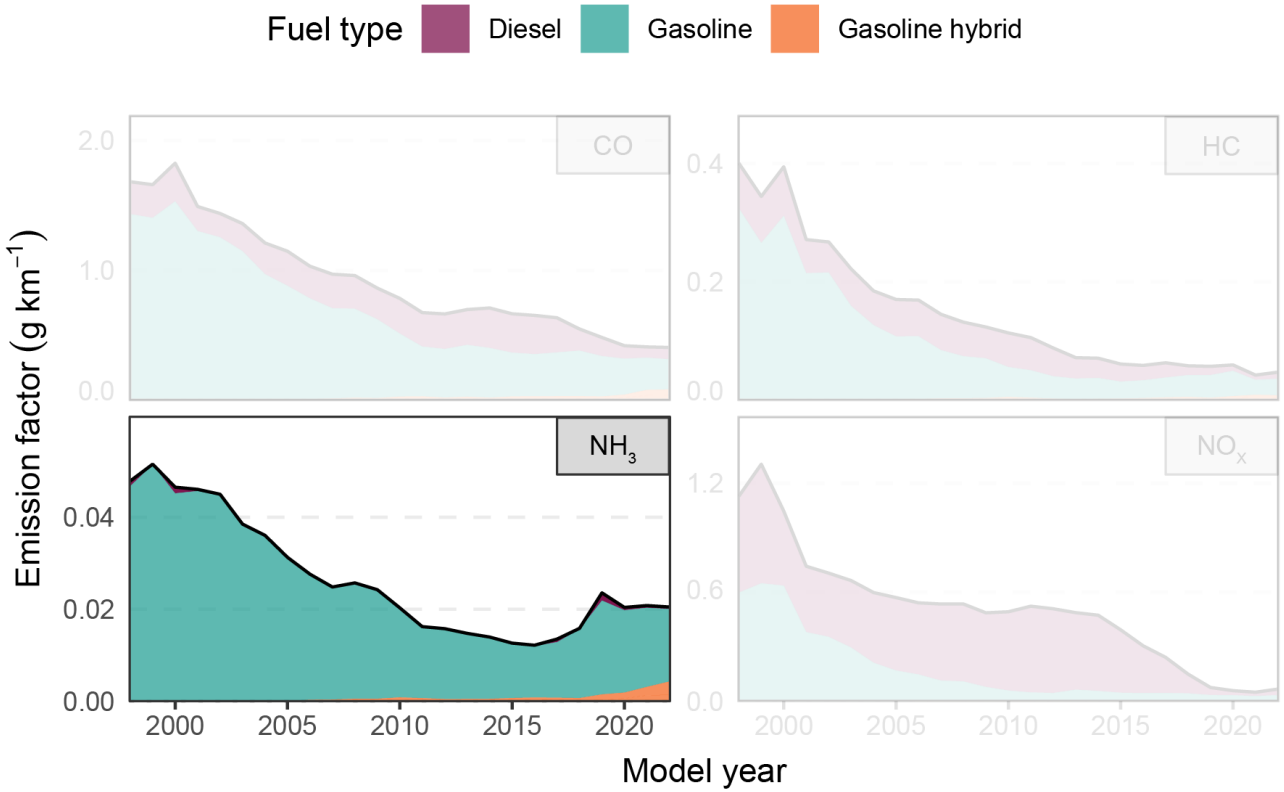
Remote Sensing III



The impact on passenger car emissions associated with the promotion and demise of diesel fuel, S. Wilson, N. J. Farren, et al., *Environ. Int.,* **2023**

Results and Insight

- Average passenger car NH_3 emission factor increases from 2015
- Dominated by the gasoline and gasoline hybrid car contribution
- Result of changes in the vehicle fleet composition (move away from diesel)



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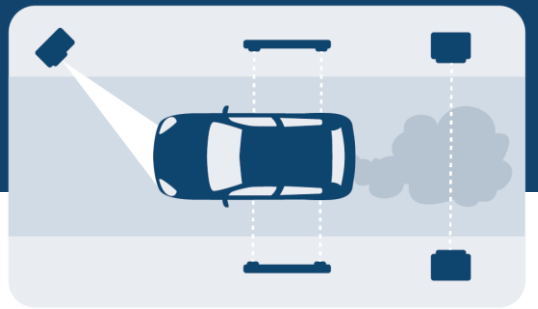
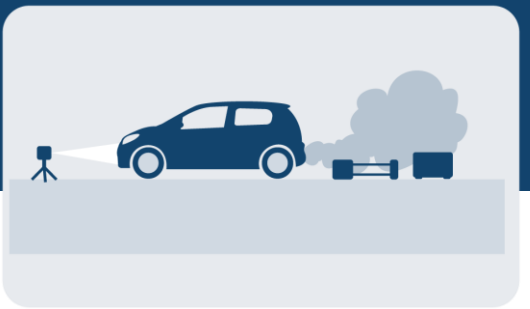


The impact on passenger car emissions associated with the promotion and demise of diesel fuel, S. Wilson, N. J. Farren, et al., *Environ. Int.,* **2023**

Average car ammonia emission factor **increased** since 2015

Due to changes in the **vehicle fleet** (shift towards gasoline)

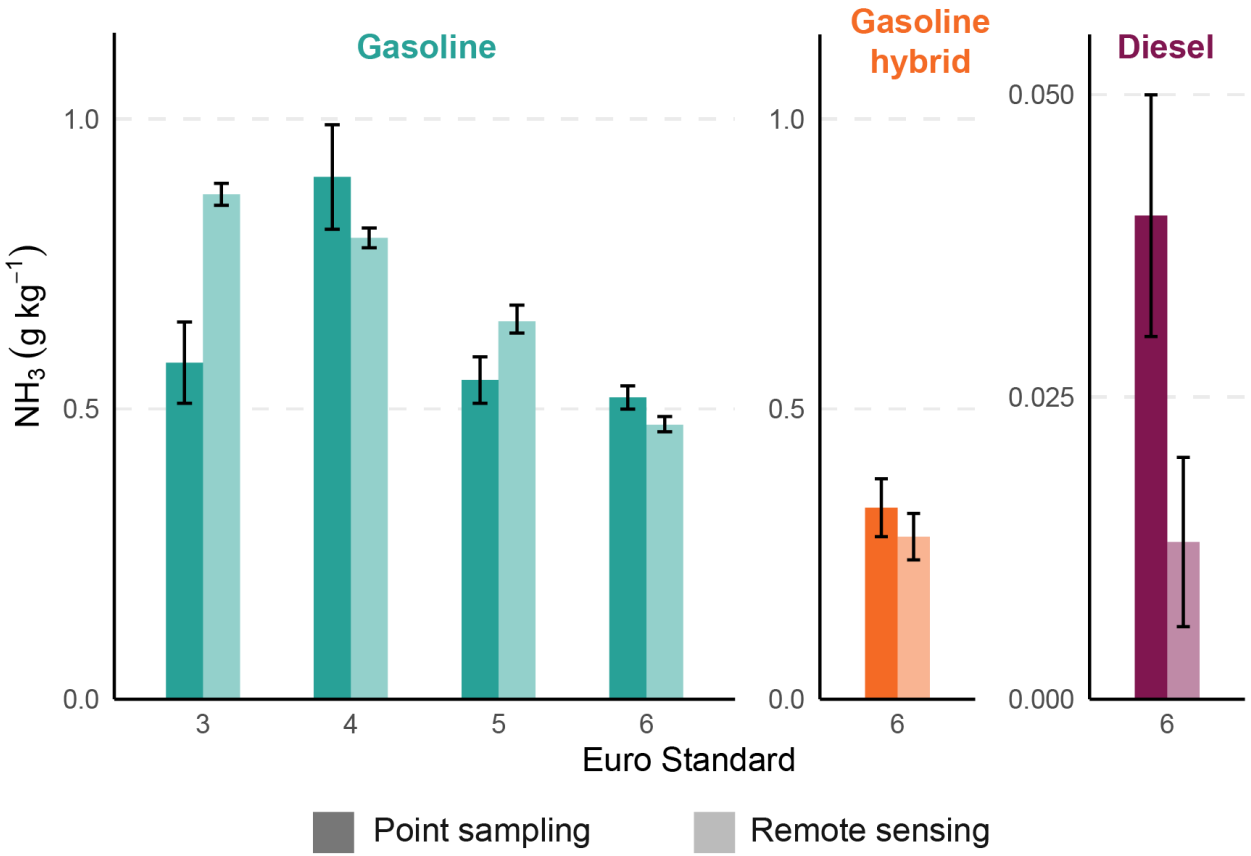
Point Sampling



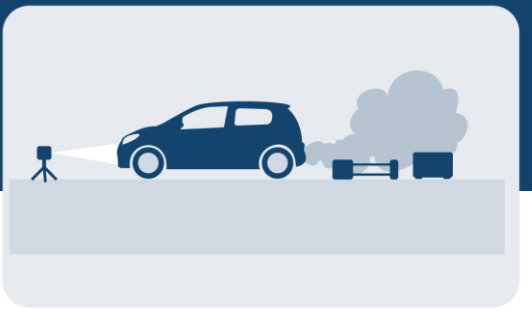
An Ambient Measurement Technique for Vehicle Emission Quantification and Concentration Source Apportionment, N. J. Farren, S. Wilson, et al., *Environ. Sci. Tech.*, **2024**

Results and Insight

- First point sampling NH_3 vehicle emissions measurements (UK)
- NH_3 emission factors reported for passenger cars (shown right)



Point Sampling



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Results and Insight

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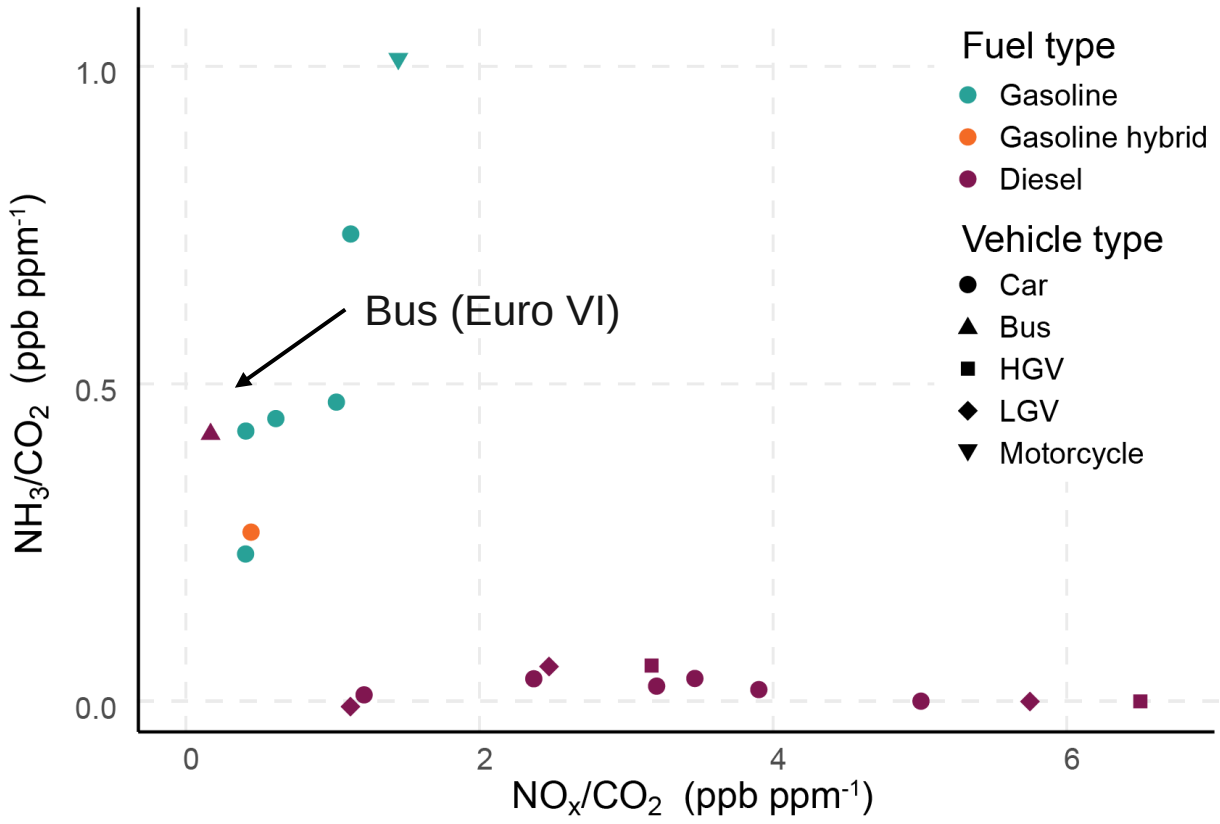
- NH_3 emission factors reported for passenger cars (shown right)
- High measured NH_3 emissions from buses



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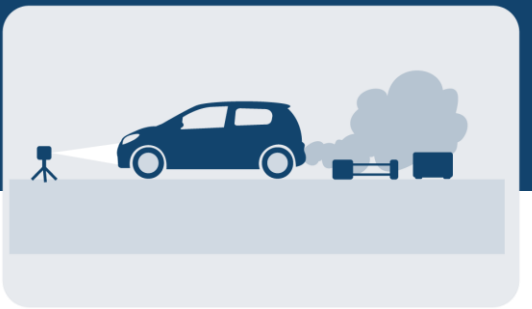

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Results and Insight

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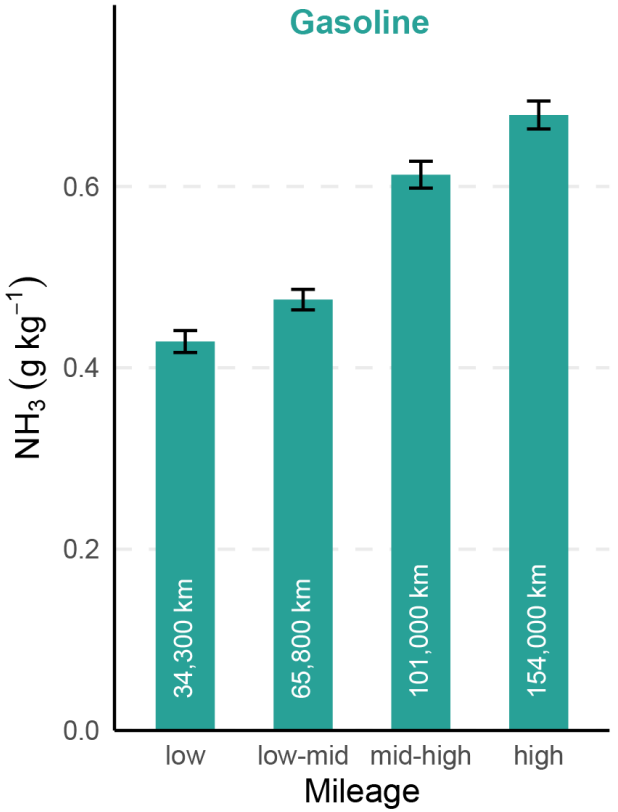
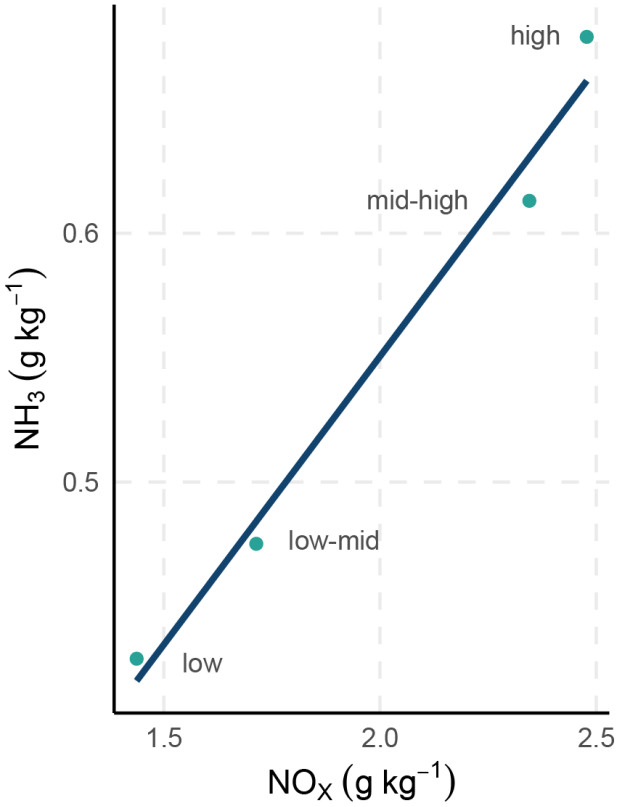
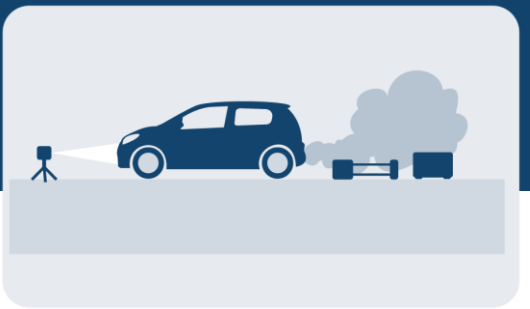
- NH_3 emission factors reported for passenger cars (shown right)
- High measured NH_3 emissions from buses
- Increasing NH_3 emissions with increasing mileage





Point Sampling



An Ambient Measurement Technique for Vehicle Emission Quantification and Concentration Source Apportionment, N. J. Farren, S. Wilson, et al., *Environ. Sci. Tech.,* **2024**

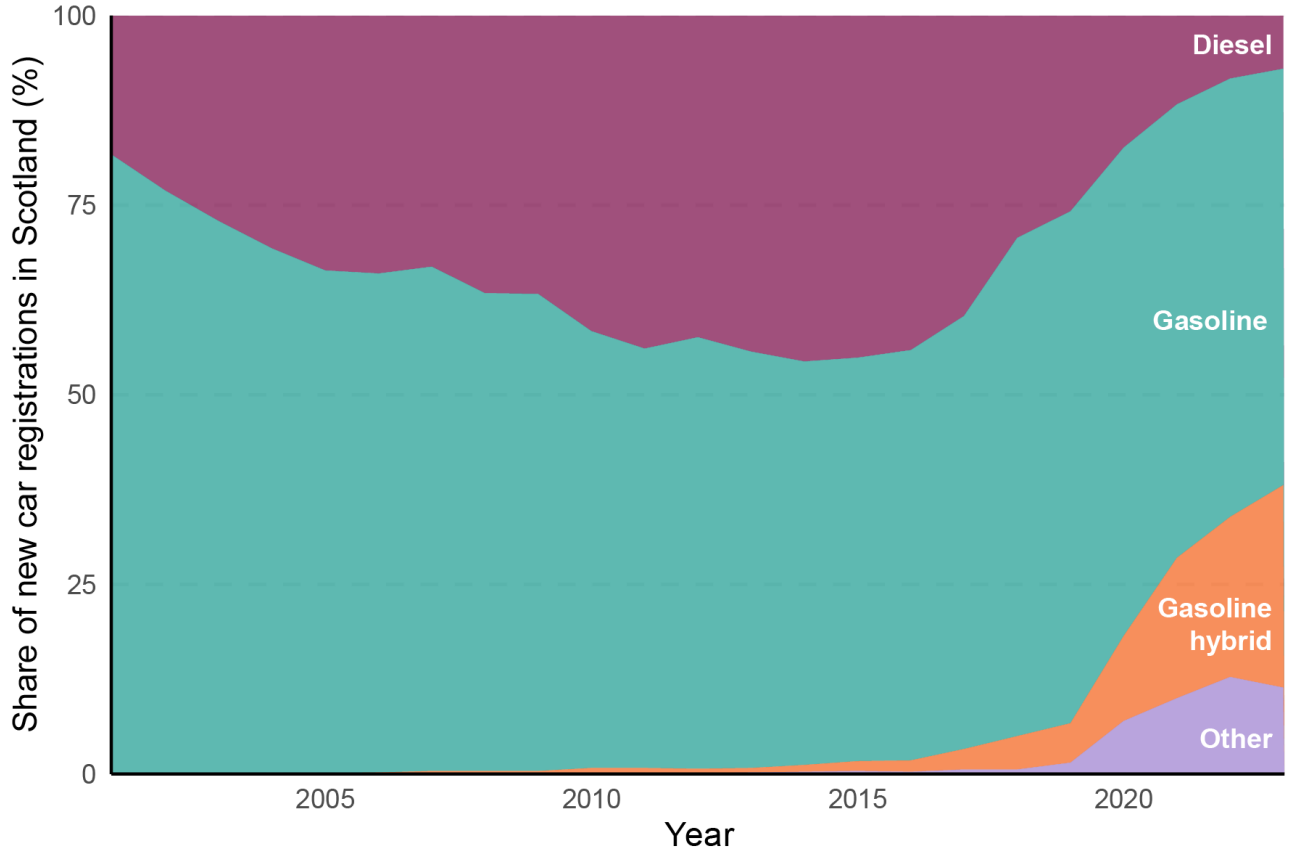
Point sampling effective for measuring vehicular ammonia

Identified diesel SCR **ammonia slip** from Euro VI buses

4.

Conclusions

Relevance to Scottish Air Quality

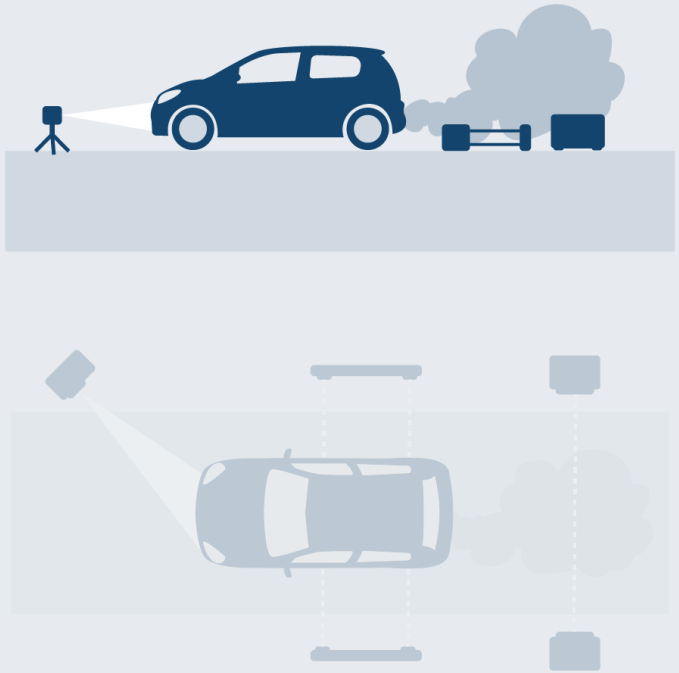


Key Points [12]

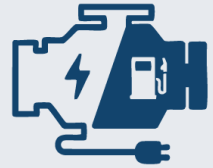
- Share of gasoline/gasoline hybrid vehicles is increasing steadily
- Ammonia emissions from these vehicles will likely increase over time
- To continue improving air quality vehicular ammonia must be considered

Future Work

Real-world NH_3 vehicle emission measurements **(point sampling)**



Focus on **gasoline hybrid** passenger cars (ageing)



Monitor diesel **SCR systems** (HGV + LGV)

Explore impacts of NH_3 on **urban air quality**

Ammonia Emissions from Vehicle Emissions Measurements

Thank you!

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Scottish Air Quality Seminar

26th March 2025

References

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