Past and Future Transport Emissions

QUANTIFY EU 6th Research Framework Programme
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QUANTIFY

- Quantification of the impact of air, sea and land traffic on the global climate
- Improved, past, present and future gridded emission inventories for transport

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- Indirect, consistency and gap filling/historical: Kristin Rypdal (CICERO)

Part of the data presented are preliminary – in particular future - and some points are complemented with data and information from other studies
Why focus on transport emissions?

- Constitute a large share of global anthropogenic emissions: In y2000 (EDGAR)
  - 37 % NOx
  - 20 % CO₂
  - 17 % CO
  - 9 % SO₂
- Historical growth in emissions has been large
  - Fuel/CO₂ doubled from 1970 to 2000
- Large future growth in fuel consumption if unconstrained
  - Transportation energy use can be 80 % higher in 2030 (EIA, IEA)
  - Larger than for non-transport sources
  - Particularly large **growth rate** in Asian developing countries, large **absolute increases** from OECD countries
- Technical mitigation options
  - Technology (global market) - fuel switch
  - International and regional regulations of exhaust emissions

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Individual emission inventories for transport

Road

Rail

Aviation

Shipping
Climate vs. Air quality focus

- QUANTIFY considers the impact of all climate forcing agents, including
  - Ozone precursors: NOx, NMVOC, CO
  - Aerosols and aerosol precursors: BC, OC and SO$_2$
- Overlaps with air quality problems
- Time frame 1900-2100
- Gridded data for 2000, 2025 and 2050
Indirect emissions

- New transport fuels may shift emissions from the consumption stage to the production stage
- Quantify includes datasets for emissions from provision of transport fuels
Overview CO₂ (fuel) 1900-2100

[Graph showing CO₂ emissions from 1900 to 2100 for different modes of transport such as Road, Rail, Rail (direct + indirect), Inland shipping, Maritime shipping, Aviation (A1), and Aviation (B2).]
Past CO$_2$
Past NOx

The graph shows the historical data of NOx emissions from different sectors:

- **Road** (solid line with diamonds)
- **Maritime shipping** (teal line with crosses)
- **Aviation** (purple line with asterisks)

Emissions are measured in Tg NOx (Tera grams of NOx) and are depicted for the years 1900 to 2000.
Road transport NO$_2$ emissions in 2000

Total road: $\sim 8.2$ Mt N/a
- road freight: $\sim 60\%$
- road passenger: $\sim 40\%$

Bonke et al. 2006 Data: I. Adab et al.
Road: Future CO₂ emissions (fuel use)

Many explaining factors, including
- Wealth ~ growth in distances traveled for both passenger and freight transport,
- Shift to car and truck transport (from cycle, bus, rail, ...),
- Engine fuel efficiency traded against more power, weight, comfort, safety features,
- Fuel prices

How will higher vehicle fuel efficiency balance the growth in transport volumes?
- Increase fuel efficiency of current internal combustion engines (+10-30% efficiency),
- Consider switch from gasoline to diesel fuel (+15% efficiency),
- De-carbonise fuel e.g. by addition of bio-fuels (-5-100% less CO₂),
- Reduce vehicle weight and power (+5-10% efficiency),
- Intelligent energy management e.g. hybrid power-train (+5-10% efficiency),

Major policy levers: Decouple
- GDP growth from transport growth,
- transport growth from road transport growth,
- transport growth from transport energy growth,
- transport energy consumption from CO₂ emissions
Road: Future emissions of air pollutants

- Exhaust emission control can probably outweigh growth in transport volumes
  - super-emitters (old or defunct vehicles, 2-stroke vehicles) are phased-out,
  - current exhaust emission standards enforced,
  - future exhaust emission standards tightened
  - the internal combustion engine replaced by electric drive (hybrid, fuel cell, .)

- Major uncertainties, not least in dynamic developing countries
  - Growth in transport demand, and notably car travel,
  - Pace of technology development,
  - Penetration of technologies,
  - Vehicle maintenance and fuel quality (fuel sulfur and lead),
  - Diesel gasoline fuel switch (PM vs CO/NMVOC)
NOx shipping 2000
Shipping present and future

- Currently ongoing discussions in the scientific literature about the current level of emissions from shipping
  - The QUANTIFY inventory is made bottom-up but is in good agreement with fuel statistics
  - Fishing included
  - Inland shipping separate

- Activity level is expected to grow until 2030 and beyond
  - Following international trade (closely related to economy/structure)

- Technology change
  - Higher energy efficiency (lower fuel) – higher NOx
  - Slow penetration
    - Long life times of vessels > 30 years
    - High expenses in changing existing engines
  - Only operational measures can have a short term effect
Shipping future NOx

- Technologies are available to reduce NOx emissions
  - IMO agreement on stricter standards for new engines (goal to reduce emissions by 30%)
  - Discussing stricter regulations
  - Fuel economy measures (without NOx penalty)
    - E.g. shape of ships, operational
  - Future from Eyring et al. (2004), J. Geophysical Research, vol 110, D17306.
SO₂

- SO₂: Shipping the largest transport source
  - Stabilisation or decline in emissions if reductions in fuel S content
    - Several regional and local regulations make a stabilisation / decline from 2025 likely
      * IMO cap on max S content
    - (Future from Eyring et al.)
Aviation future

- Fuel consumption is expected to grow strongly (5% per year) until 2025
  - Strong correlations with GDP historically
  - Improved fuel efficiency is expected

- No prospects for fuel switching over the next 30 years

- NOx, CO and NMVOC from aviation are regulated (ICAO certification of engines)
  - Fuel penalty in NOx control
  - Considerations of noise and safety
  - Resistance for stricter NOx regulations by industry
  - Slow penetration – long craft lifetime (25 years)

- NOx emission factors are expected to grow in the future unless a change in policy
- Total emissions may be higher than shipping after 2050
Bunker fuels

- Shipping and aviation international bunker emissions are excluded from national totals in emission inventories reported to UNFCCC and EMEP
- Reported on an aggregated basis allocated to the country where the fuel was sold
- Allocation is part of ongoing policy discussions under UNFCCC
- Consequences for national policies
Future – mode shifts

- Global trend towards using faster and more energy intensive modes (car, truck, airplane)
  - Time spent on travel is more or less constant in all cultures!
    - Distance travelled makes the difference
  - High speed rail may substitute shorter air trips and longer passenger car trips
  - Passenger cars vs. public transport
  - Freight: car vs. Truck

- Major uncertainty in predicting future emissions
  - Policies and preferences
Quantify – inclusion of developing countries’ experts

- The emission and projection team of Quantify will from late 2006 be strengthened with experts from China, India and Russia
- These experts will contribute to verification of the transport inventories using their national available bottom-up data
  - Tsinghua University
  - Center for Sustainable Transportation, China Academy of transport sciences
  - Indian central institute of road transport
Conclusions

- Transport activities are expected a continuous growth over the next 30 years, especially in developing countries.
- Improved fuel efficiency is expected to reduce growth in fuel for all modes.
- New regulatory standards will be important in reducing emissions of air pollutants for road, shipping, but likely not for aviation.
- Slow penetration of new technologies for rail, shipping, and aviation since these are targeting new engines.
- Only road transport can drive short-term reductions (2030) of air pollutants.
  - tighter shipping NOx standards will likely contribute to neutralize the result of higher transport demand.
  - aviation NOx emission will increase.
- Developing country technology implementation, fuel standards, and maintenance is an uncertain factor in determining future emissions of air pollutants from road transport.