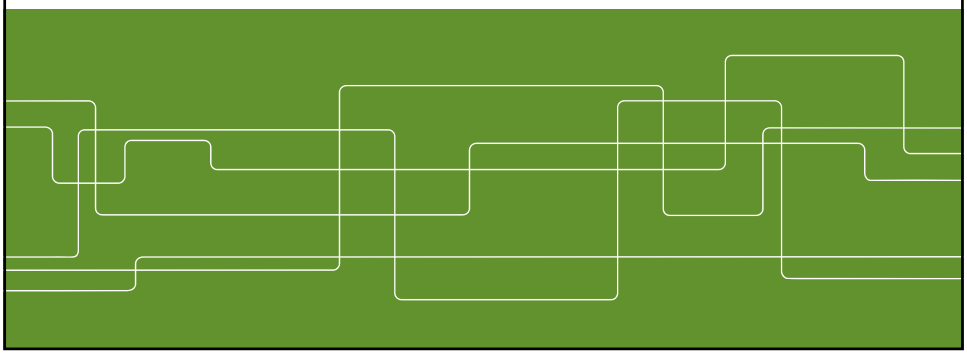
Local Emissions and Air Quality

2015-03-25



Today

Overview of Local Emissions
Case Study on EU Project ”SUDPLAN”

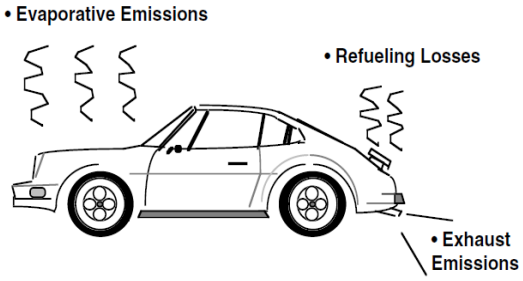
LOCAL EMISSIONS

Transport as an Emissions Source

Internal Combustion Engines

- Convert Fossil Fuels + O_2 into H_20 & CO_2
- Additional by-products:
  - Carbon Monoxide (CO)
  - Oxides of Sulfur (SO_x)
  - Oxides of Nitrogen (NO_x)
  - Lead Aerosols
  - Sulfate Aerosols → Particulate Matter (PM)
  - Soot/Ash → PM

Sources of Auto Emissions



EPA 1994

Sources of Auto Emissions

Diurnal

- Daily rise in ambient temperature causes fuel tank to heat, some fuel to evaporate

Running Losses

- Hot engine & exhaust system can vaporize fuel

Hot Soak

- Engine remains hot after car is stopped, so fuel evaporation can continue

Refuelling

- Some vapors released when gas cap is opened

Exhaust Emissions

Perfect Combustion

- Fuel + Air → CO_2 + H_2O

Typical Combustion

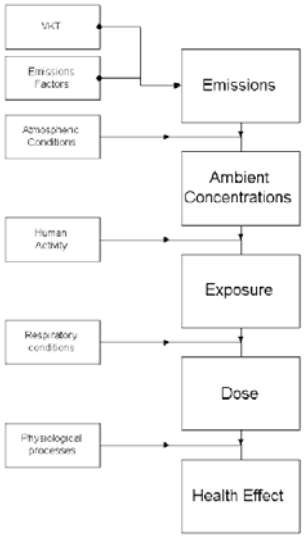
- Fuel + Air → Unburned HC + NO_x + CO + CO_2 + H_2O

Sources of Particulate Matter (Thorpe & Harrison, 2008)

Sources

- Exhaust
- Brake wear
- Tire wear
- Road surface abrasion & resuspension

Pathway from Transport Emission to Health Effect (Gorham 2002)



Lead

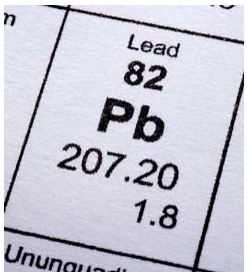
Additive to fuels, to cheaply increase octane

Now banned in most developed countries, but still legal in some parts of the world:

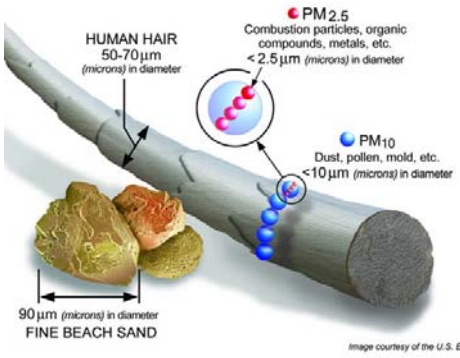
- Algeria, Iraq, Yemen, Myanmar, N Korea, Afghanistan

Clear link to:

- Cardiovascular disease
- Premature death
- Behavioral and developmental problems in children



Particulate Matter (PM)



Worst are fine particulates:
< 2.5 microns (PM2.5)

Also of concern are particulates
< 10 microns (PM10)

Long-term effects on respiratory functions

Causal mechanisms are complex, not fully understood

US EPA, 2015

Volatile Organic Compounds (VOCs)

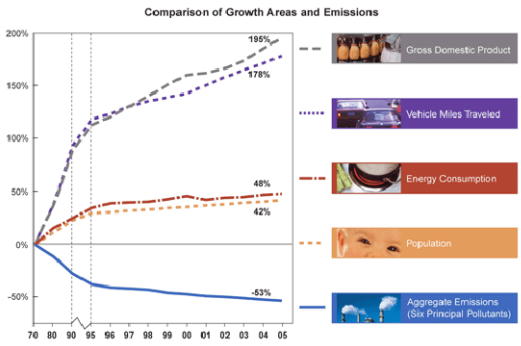
Released when fuel isn't completely burned

Contributes to Ozone formation, when reacting to sunlight and nitrogen

Ozones:

- Short-run impairment to respiratory function
- Unclear long-term effects

Can contribute to PM formation



US EPA, 2015

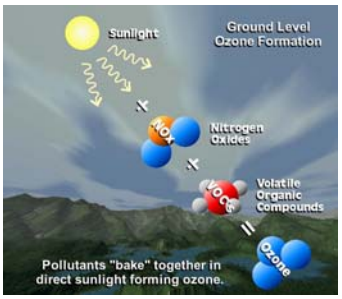
Oxides of Nitrogen (NOx)

Formed when Nitrogen in the ambient air is split and oxidized by combustion

Direct health effects:

- Impairs respiratory function
- Can damage lung tissue

Interacts with VOCs to form Ozone



US EPA, 2015

Carbon Monoxide (CO)

Can cause:

- Oxygen deprivation
  - Cardiovascular & coronary problems
- Increased risk of stroke
- Impaired learning ability, dexterity, sleep

Especially hazardous in confined areas:

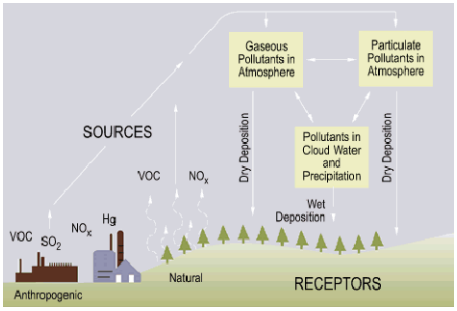
- Tunnels, overpasses, dense urban areas

Oxides of Sulfur (SOx)

Health Effects

- Bronchial function

Industrial sources much greater than transport sources



US EPA, 2015

% of Emissions due to Vehicles (Gorman 2002)

City/region	Carbon monoxide	Volatile organic compounds	Oxides of nitrogen	Sulphur dioxide	Particles
Beijing	39	75	46	n.a.	n.a.
Budapest	81	75	57	12	n.a.
Cochin	70	95	77	n.a.	n.a.
Colombo	100	100	82	94	88
New Delhi	90	85	59	13	37
Kathmandu	n.a.	n.a.	n.a.	3	12
Lagos	91	20	62	27	69
Mexico City	100	54	70	27	4
Organisation for Economic Cooperation and Development	70	31	52	4	14
Santiago	92	81	82	25	10
São Paulo	97	89	96	86	42

Causes of Vehicles' Air Pollution

By Mechanism (Gorham 2002):

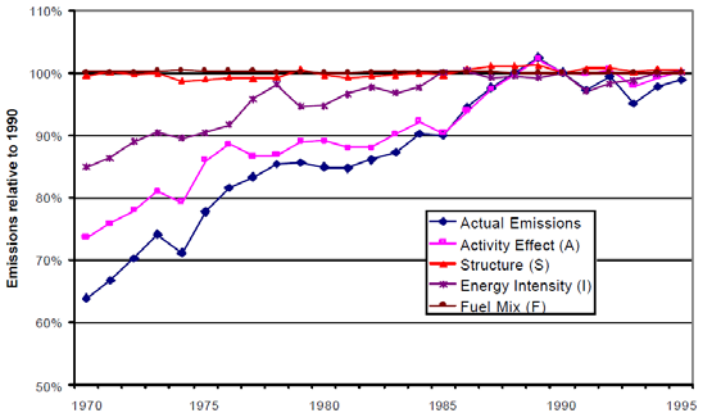
- **Overall use** of vehicles
- Use of old and outdated **vehicle technology**
- Poor vehicle **maintenance**
- Unavailability or improper use of appropriate **fuels**
- **Atmospheric, topographic,** and **climatalogical** aspects of metropolitan areas

Causes of Vehicles' Air Pollution

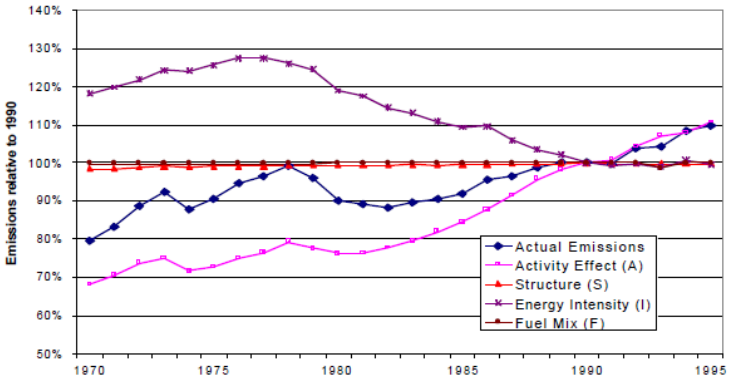
By Activity (Shipper 2000):

- **Travel activities** – total demand
- **Structure** – use of energy-intensive modes
- **Energy intensity** – energy-intensity of same mode
- **Fuel Mix** – typical composition of fuels for a mode

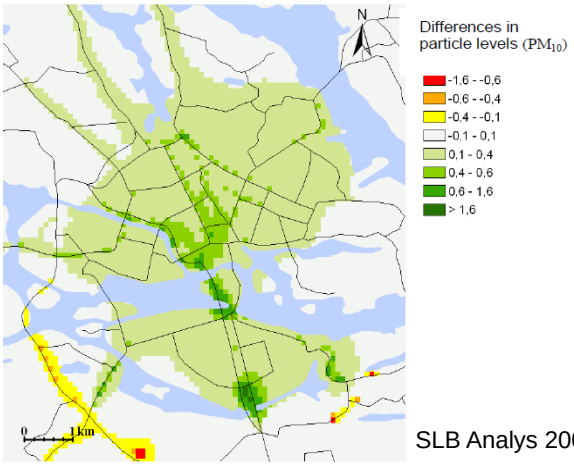
Trends for Sweden (Schipper et al 2000)



Trends for USA (Schipper et al 2000)



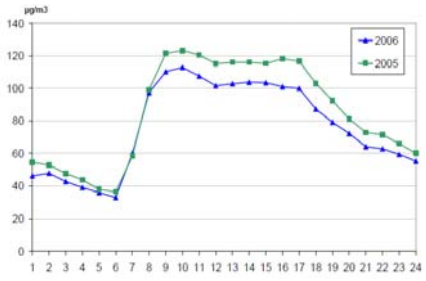
Traffic Geography



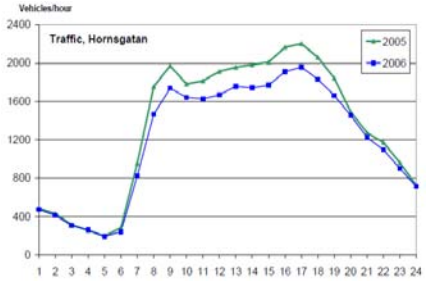
SLB Analys 2006

Traffic Profile on Hornsgatan

NOx, in µg/m3



Traffic, in Veh/Hour



SLB Analys 2006

Traffic Composition on Hornsgatan (SLB Analys, 2010)

Diesel engines 30% of traffic

- Cause 60% of NOx

Heavy vehicles 3% of traffic

- Cause 40% of NOx

Petrol vehicles 53% of traffic

- Cause 23% of NOx

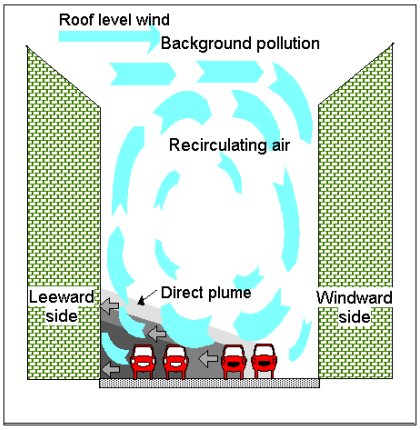
Ethanol vehicles 13% of traffic

- Cause 3% of NOx

Case Study

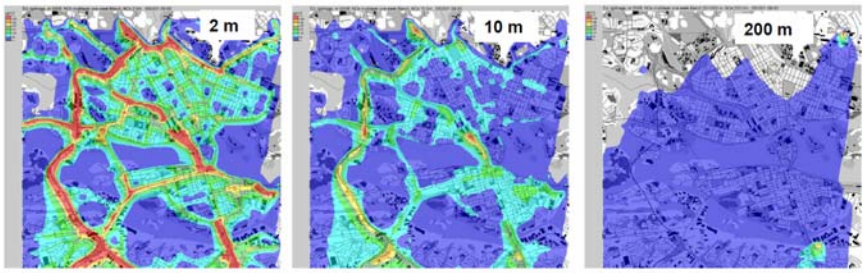
"SUDPLAN" APPLIED TO THE STOCKHOLM BYPASS

Air Pollution in Urban “Street Canyons”



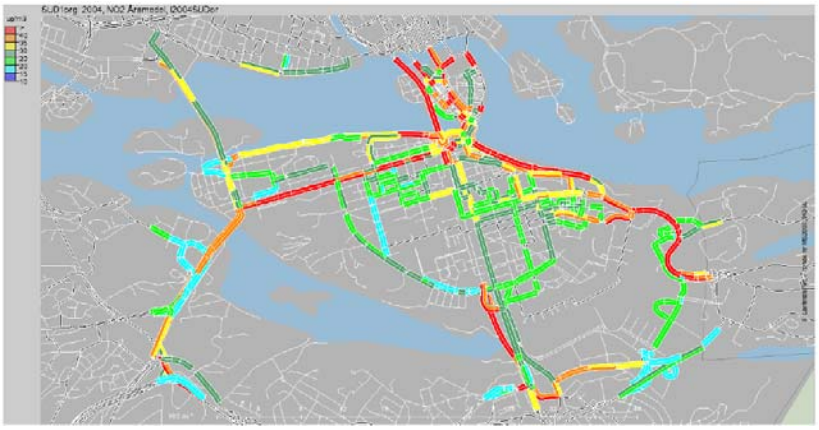
Aarhus University, 2015

NOx Concentrations by Height Morning Peak Period



SUDPLAN, 2011

Simulated NO2 concentrations with Canyon Effects (from SIMAIR)

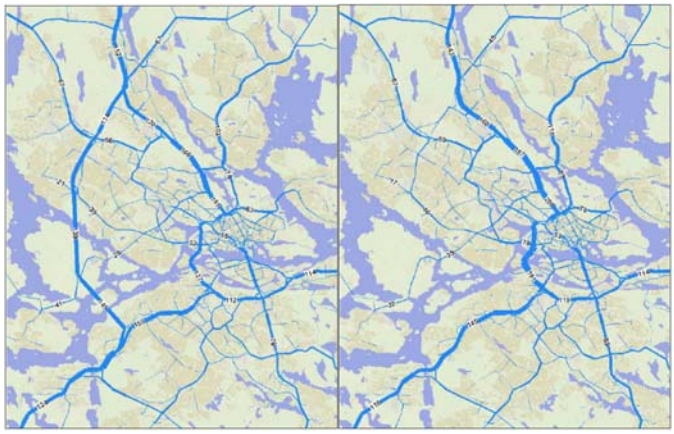


SUDPLAN, 2011

Stockholm Bypass
Förbifart Stockholm

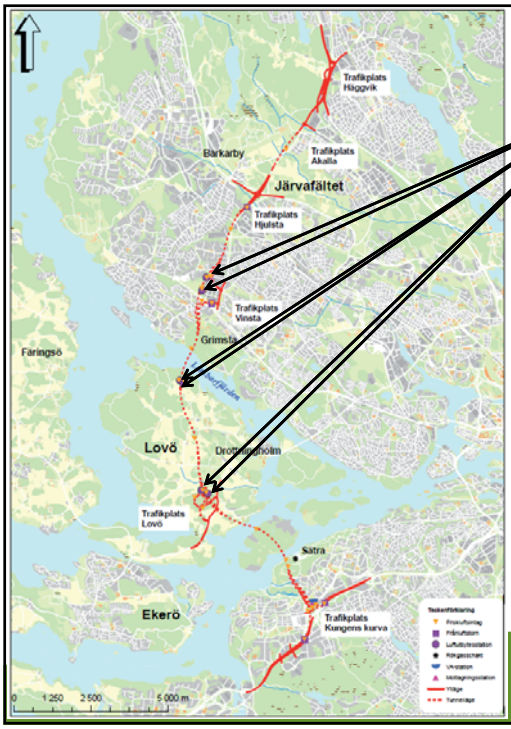
Length: 21 km (18 km in tunnels)
Construction: 2014 – 2022+
Cost: 27,6 billion SEK

Projected Traffic in 2035 (Sampers)



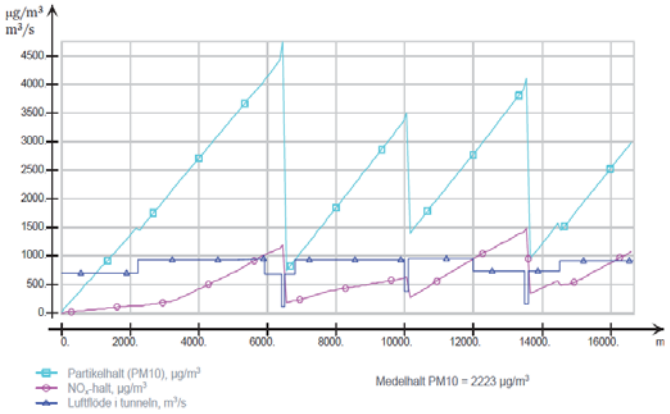
SUDPLAN, 2011

Ventilation Towers



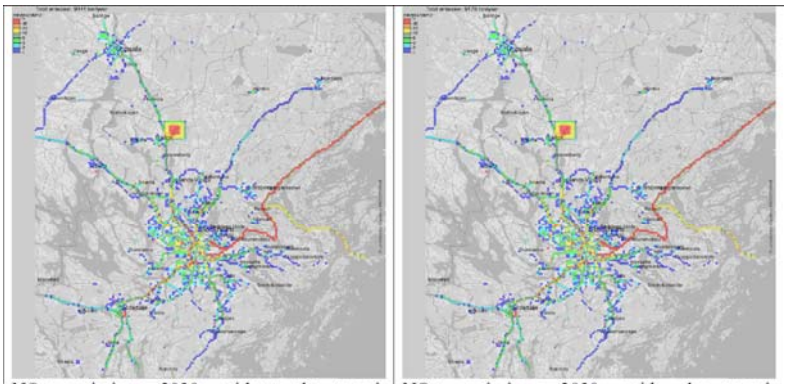
Trafikverket, 2011

Emissions Along the Tunnel



Trafikverket, 2011

NOx emissions in 2030

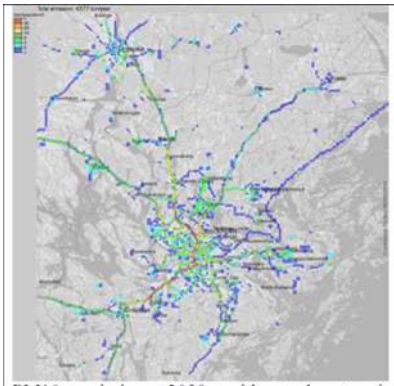


NOx emissions 2030, without the transit road/tunnel (9141 t/y).

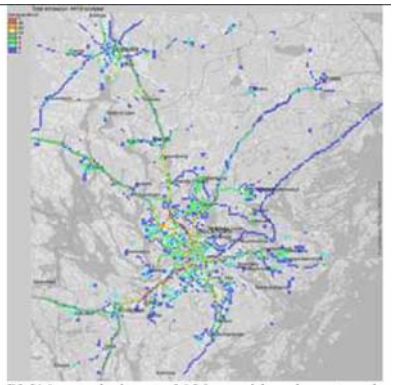
NOx emissions 2030, with the transit road/tunnel (9175 t/y).

SUDPLAN, 2011

PM10 Emissions in 2030



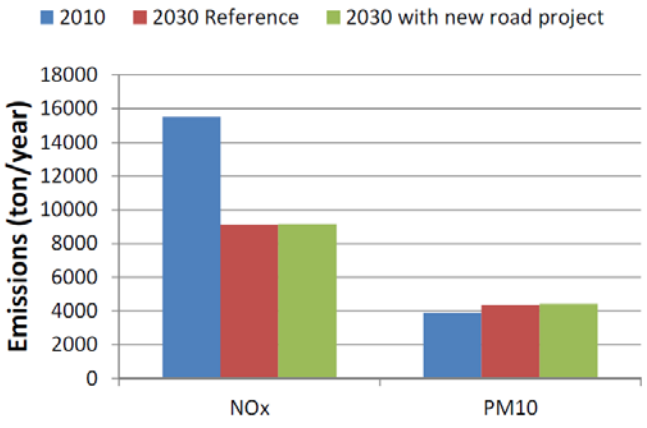
PM10 emissions 2030, without the transit road/tunnel (4377 t/y).



PM10 emissions 2030, with the transit road/tunnel (4419 t/y).

SUDPLAN, 2011

Summary



SUDPLAN, 2011

Discussion in Groups

Find a partner you don't know

Discuss the following questions:

1. What are the main environmental concerns with the Stockholm Bypass?
2. If forecasts show no change in NOx and PM10 due to the Bypass, what is the main remaining concern for local emissions?
3. What might the analysis here have missed? Or incorrectly assumed?