



Using UBM and OSPM for AQ Assessment and Impact Assessment - examples from Denmark

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Presentation

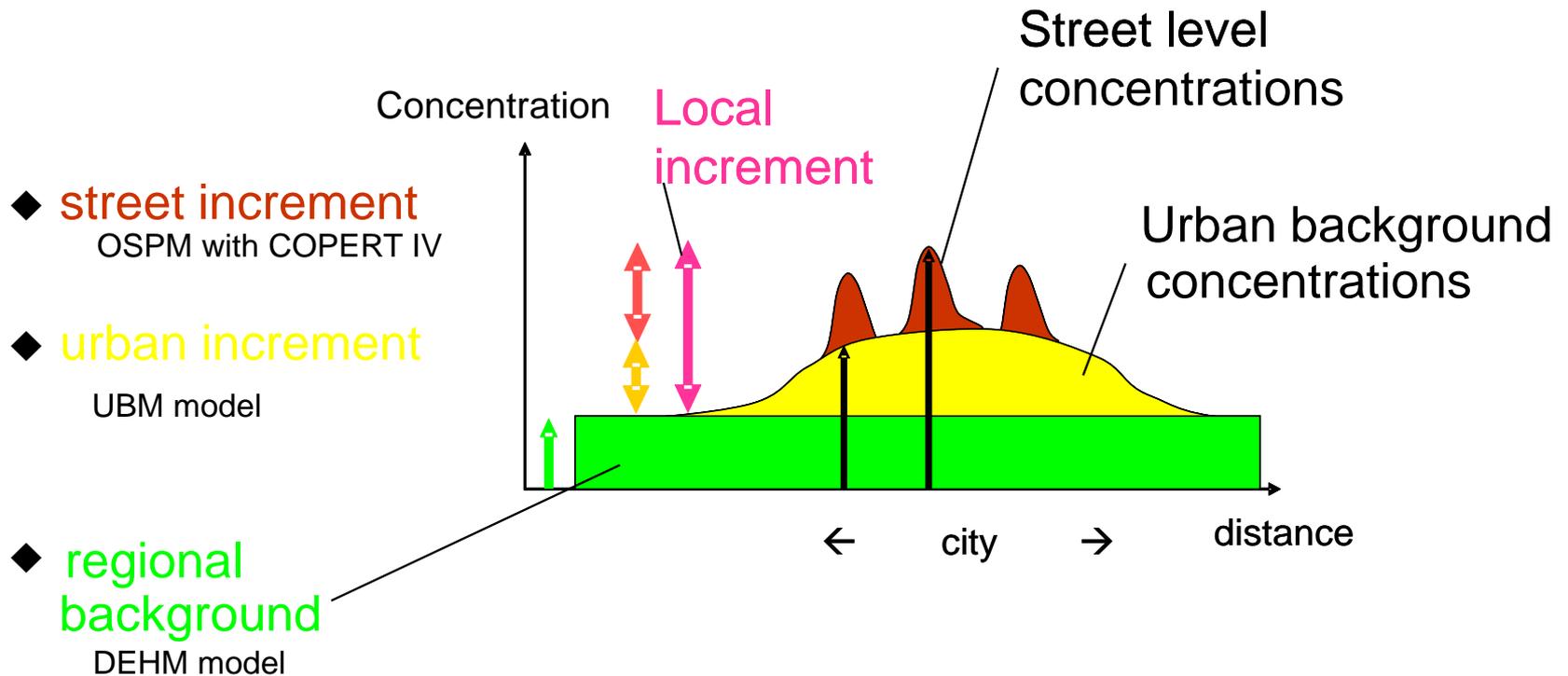
- › **Air pollution assessment system**
- › **Emission assessment**
- › **Air quality assessment**
- › **Health impact assessment and external costs of air pollution**
- › **Impact assessment of policy measures**



Air Pollution Assessment System

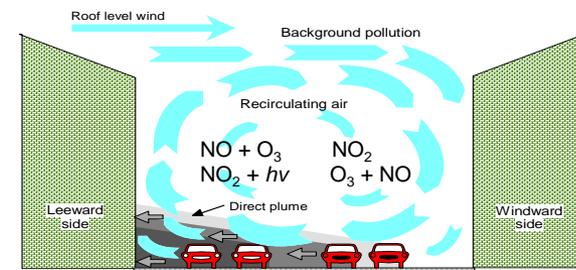
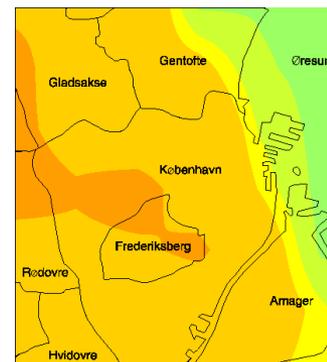
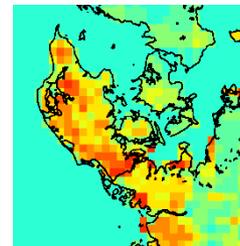
- › **Decision-support for policy makers and administrators within:**
 - › **spatial distribution of air quality levels**
 - › **comparison with air quality limit values**
 - › **past, present and future emissions and air quality levels**
 - › **total emissions and their distribution on different sources**
 - › **the attribution of emissions to air quality levels**
 - › **impact assessment of different policy measures on emissions and air quality levels**

Modelling intra-urban variability



AQ models

- › **Regional background concentrations**
 - › DEHM (Danish Eulerian Hemispheric Model)
 - › Adjusted for PM mass closure
 - › Geographic resolution 5,6 km x 5,6 km in DK
- › **Urban background concentrations**
 - › Urban Background Model (UBM)
 - › Coupled to DEHM in one hour time step
 - › Geographic resolution 1km x 1km
- › **Street concentrations**
 - › OSPM (Operational Street Pollution Model)
 - › AirGIS (automatic generation of input data to OSPM about traffic and buildings)
 - › Geographic resolution: address level



AirGIS

Automatic generation of street configuration data from digital maps and databases for OSPM:

1. General building height
2. Building height in wind sectors
3. Width of street
4. Street orientation
5. Distances to street intersections
6. Traffic data

Avenue program (ArcView 3x)
more than 10.000 lines





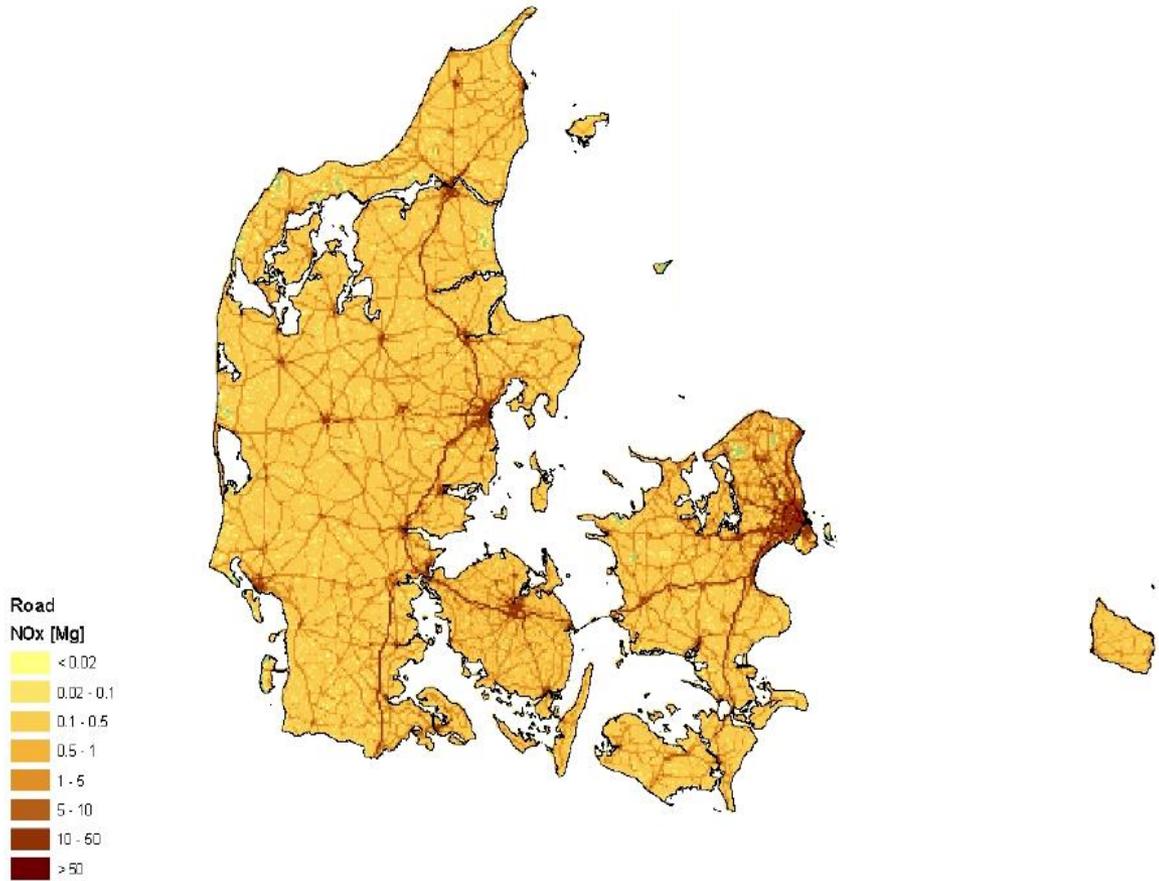
Assessment of emissions

- › **Urban emission inventories for UBM provide information about:**
 - › **total emissions and their distribution on different sources**
 - › **visualise spatial distribution on a grid**
 - › **may be available for different scenario years for future predictions**

- › **COPERT emission module of OSPM® provides information about:**
 - › **different vehicles classes**
 - › **engine size and emission classes**
 - › **fuel types**
 - › **different scenario years**

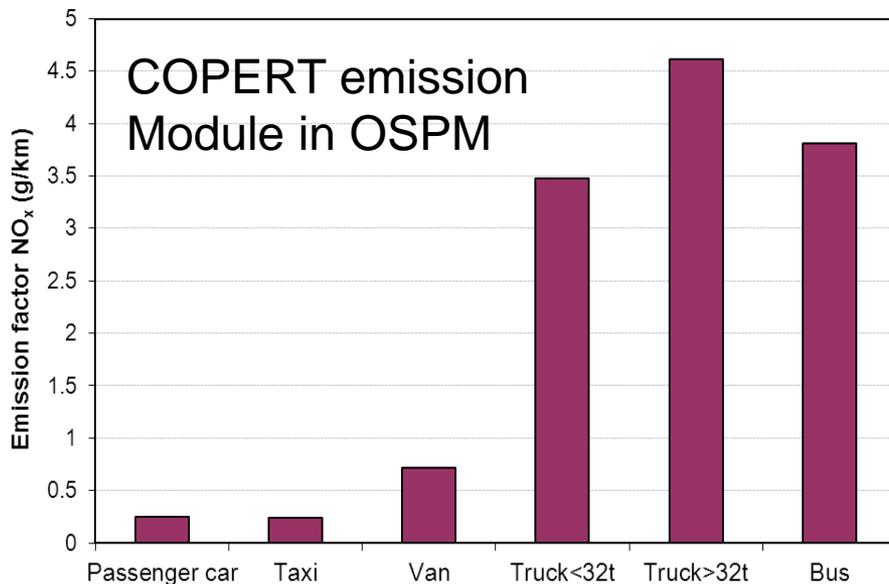
Emissions on 1x1 km² for UBM

- > National emissions of all emissions sources are spatially distributed based on geographic criteria (SPREAD model)
- > e.g. road emissions are distributed based on km travelled in grid cells based on GIS network with traffic data



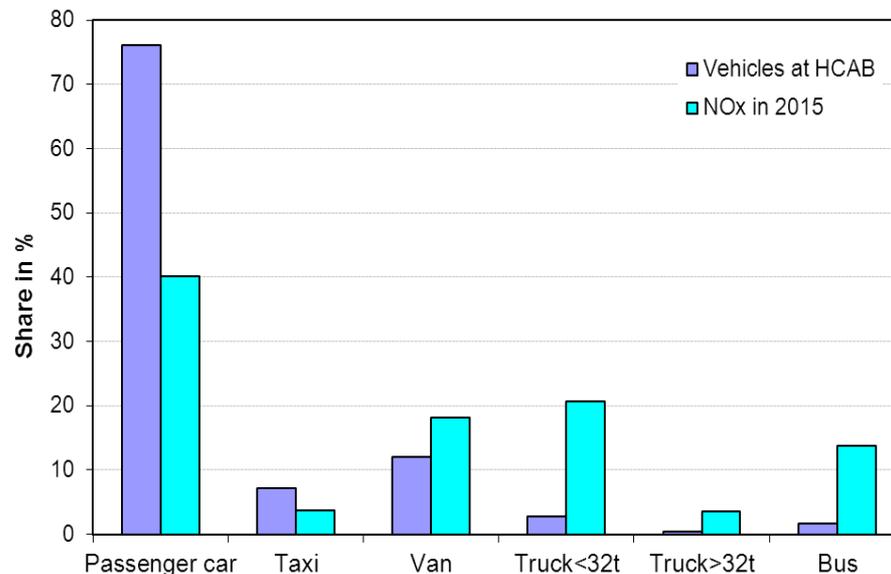


NO_x apportionment at busy street in CPH



> **Heavy-duty vehicles have much higher emissions factors than light-duty vehicles**

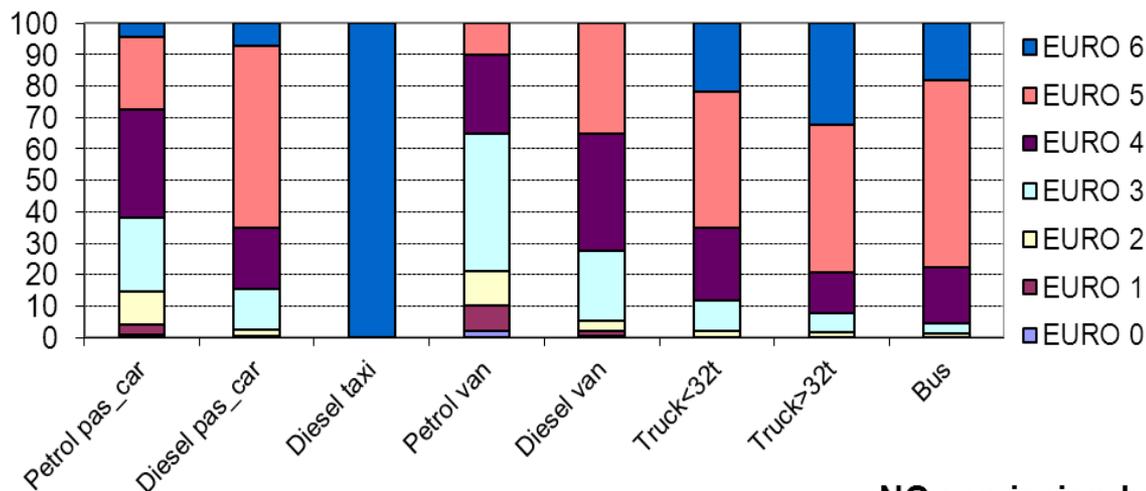
> **4.7% heavy-duty vehicles contribute about 40% of NO_x in 2015**





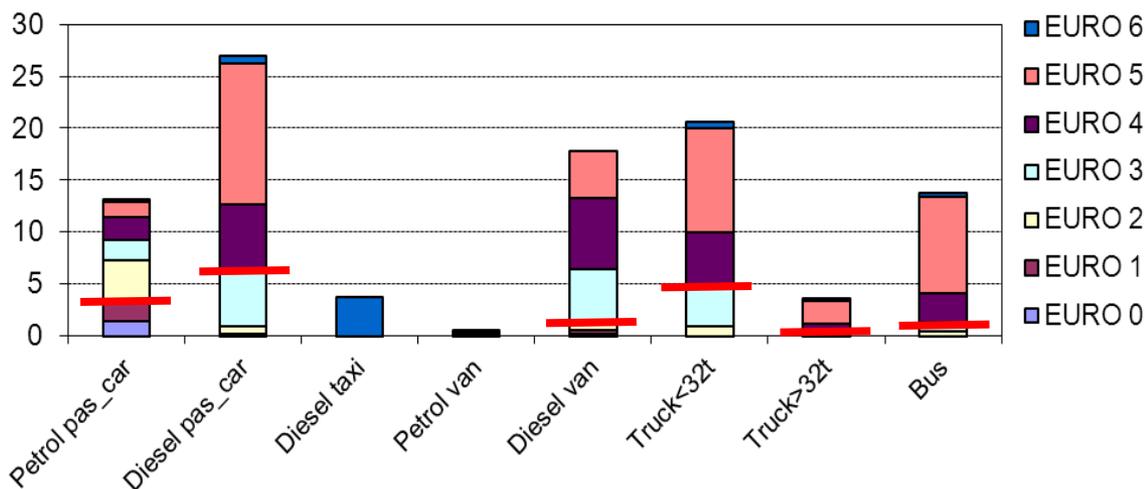
NOx emissions by Euro classes at HCAB in 2015

Distribution of Euro classes in Copenhagen in 2015 (%)



COPERT emission
Module in OSPM

NOx emission by Euro class in CPH in 2015 (%)

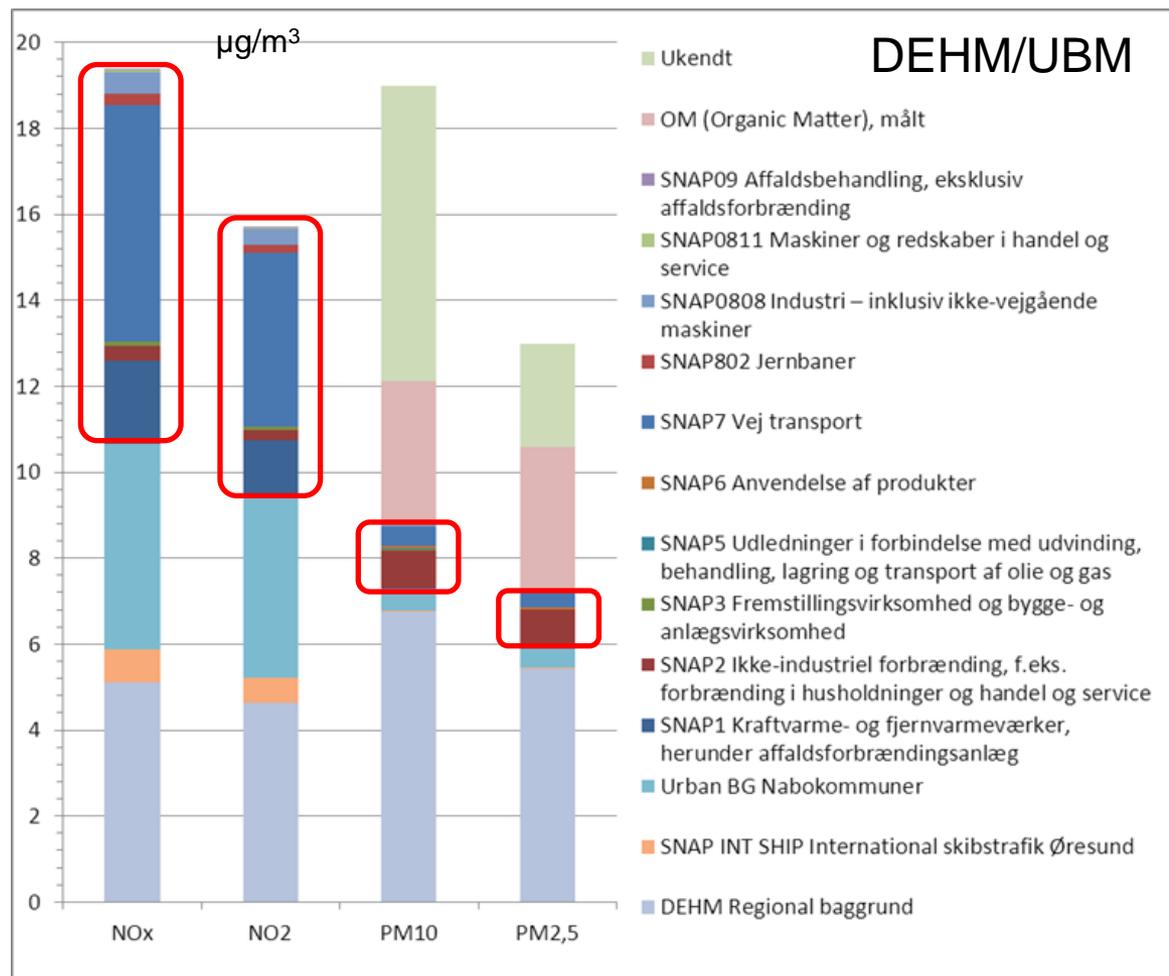


- > Possible regulation of <=Euro 3 (diesel) and <=Euro 1 (petrol)
- > Limited contribution



Source attribution to urban background concentrations in Copenhagen

Contribution from emission sources *in* Copenhagen to urban background conc. *in* Copenhagen



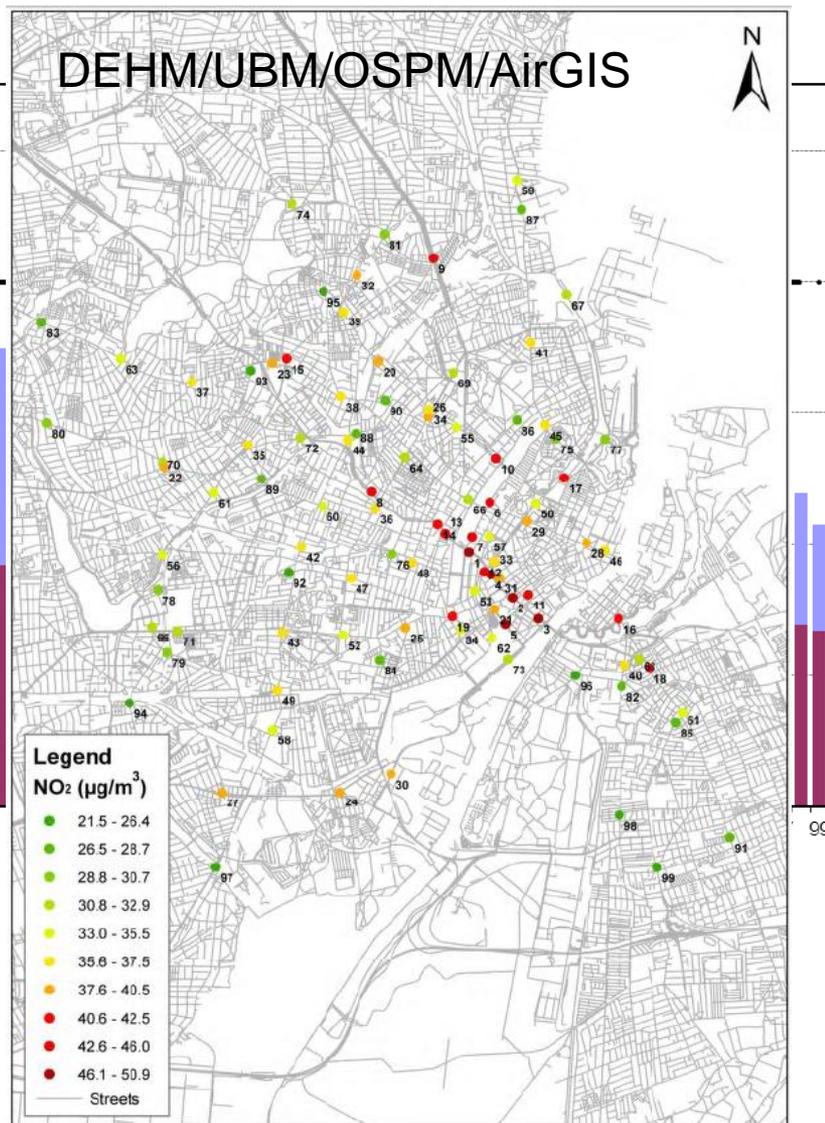
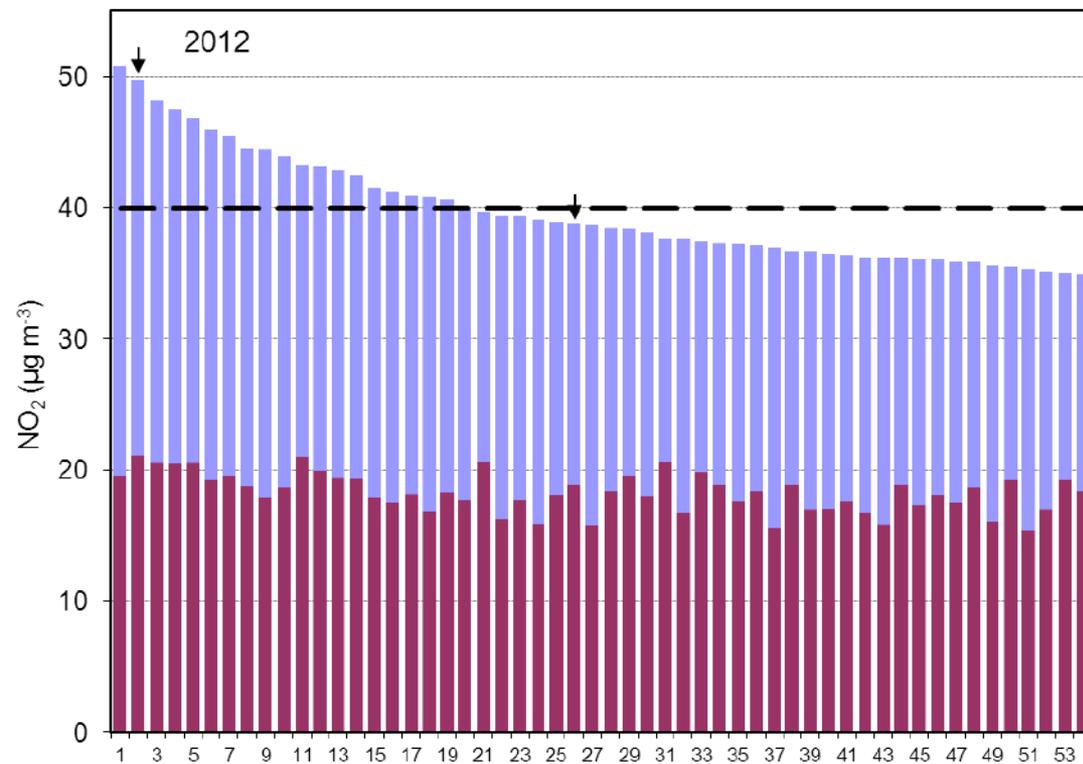


Air quality and health impact assessment

- › **AQ information at the regional scale, urban background scale and street scale**
- › **past, present and future air quality levels**
- › **visualise spatial distribution of air quality levels**
- › **validated models can provide comparisons air quality limit values or guidelines can be carried out and an assessment of exceedances of limit values**
- › **impact assessment on health effects and related social costs of air pollution**

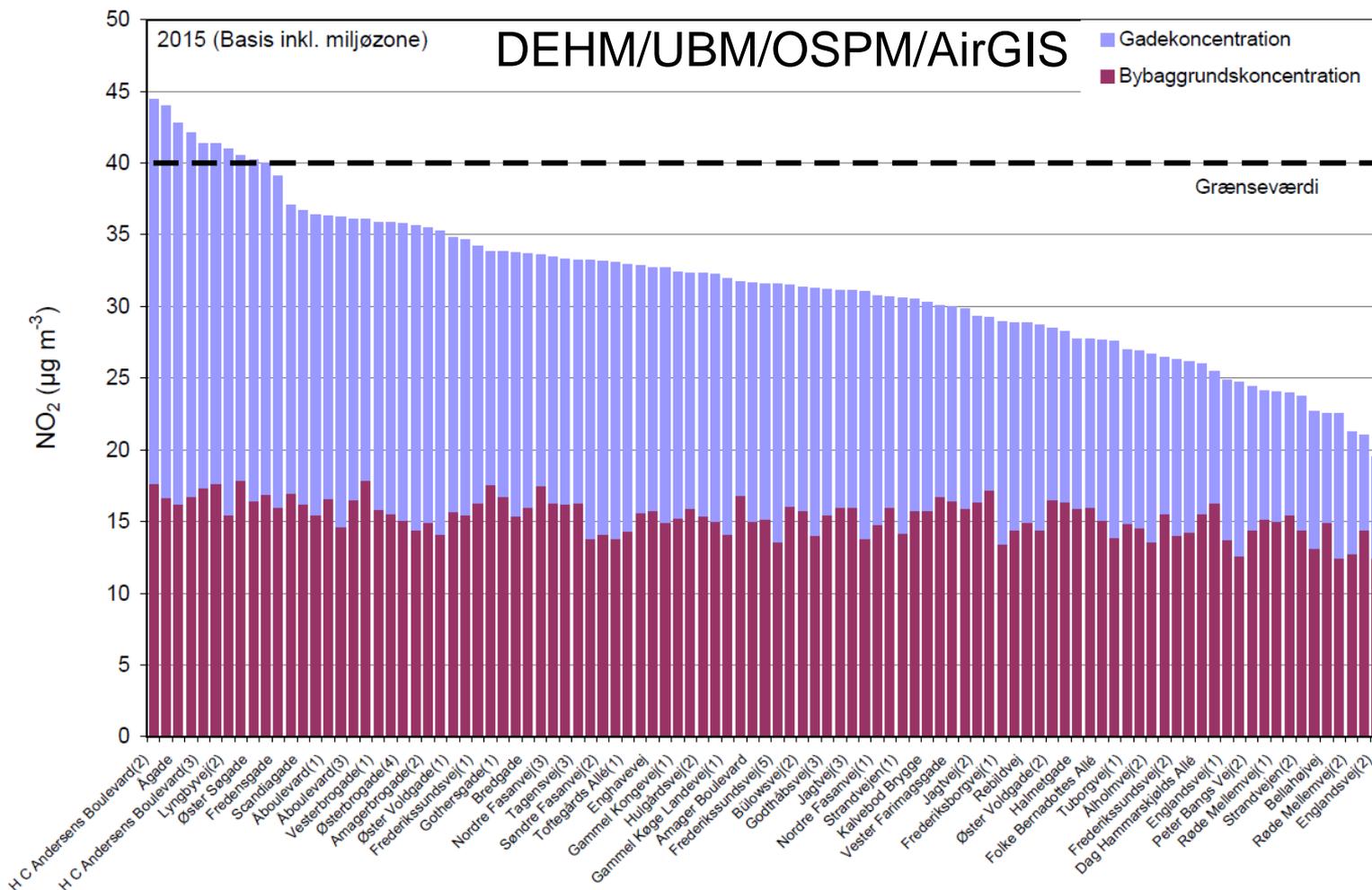


NO₂ exceedances in Copenhagen 2012





Predicted NO₂ exceedances in 2015





Website for Air Quality at Your Street

AARHUS UNIVERSITET
DCE - NATIONALT CENTER FOR MILJØ OG ENERGI

Datalag

- Baggrundskort
 - Google Hybrid
 - Google Satellite
 - OpenStreetMap
- Luftforurening i 2012
 - NO₂ (kvælstofdioxid)
 - PM_{2.5} (partikler < 2,5 µm)
 - PM₁₀ (partikler < 10 µm)

Navigation | Vælg udsnit | Vis Danmark | Zoom ind | Zoom ud | Tilbage | Frem | Mål afstand | Værdi

Værktøjer

5,95 E, 56,28 N

100 km

Info

Signaturforklaring

NO₂ (kvælstofdioxid)

OpenStreetMap

- Motorvej
- Motortrafikvej
- Hovedvej (primærute)
- Hovedvej (sekundærute)
- Uasfalteret vej
- Hjulspor
- Stikvej
- Ridesti
- Cykelsti
- Gangsti
- Jernbane
- Undergrundsbane
- Letbane og sporvogn
- Kabelvogn og stolleift
- Landingsbane og taxibane
- Lufthavnsforplads og terminal
- Administrativ grænse
- Skov
- Skov
- Golfbane
- Park
- Boligområde
- Seværdighed
- Fælleed og eng
- Detailhandelsområde
- Industriområde
- Erhvervsområde
- Hede
- Sø og reservoir

Om data

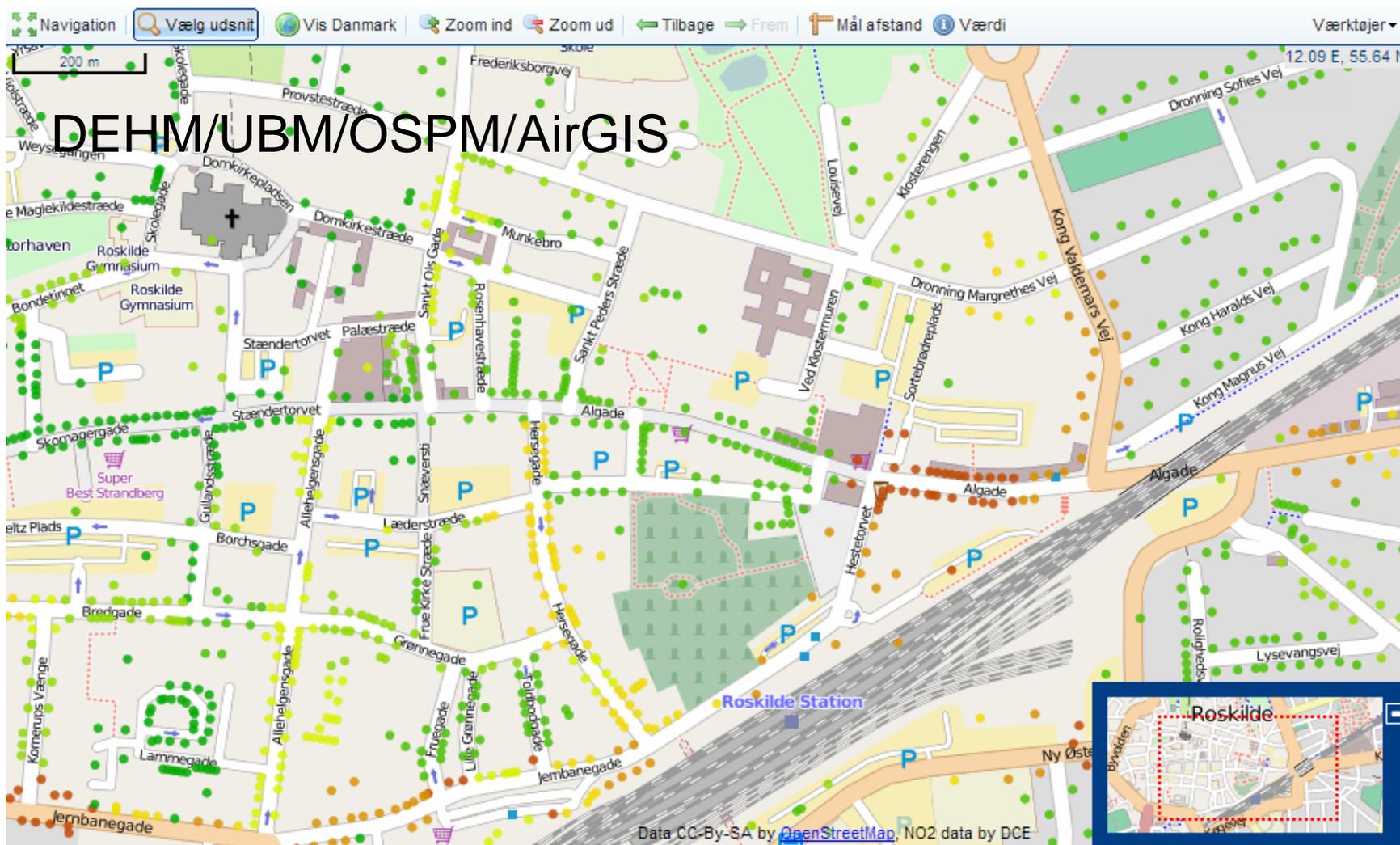
Brugervejledning

Data CC-BY-SA by [OpenStreetMap](#), NO₂ data by DCE

Indtast adresse (gadenavn husnummer kommunenavn)



Street concentrations of NO₂



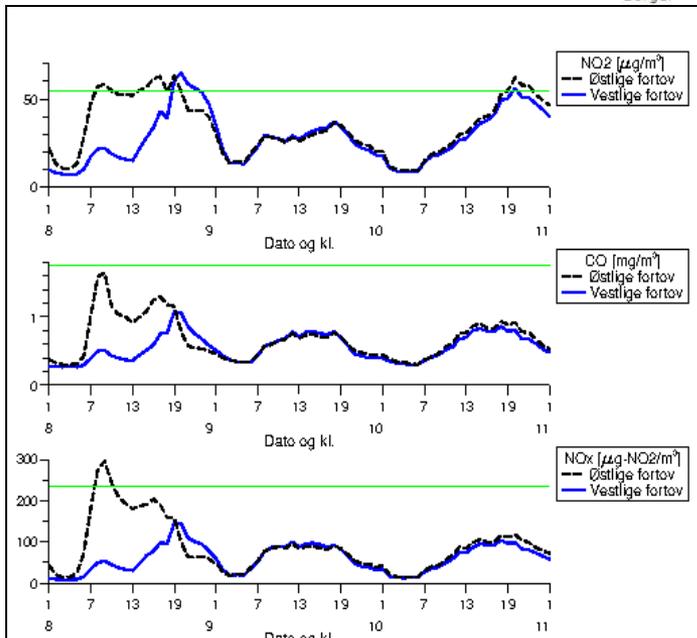


3-day forecast of air quality in Copenhagen

DEHM/UBM/OSPM plus meteorological forecast



< Forside
< Borger



Luftudsigt

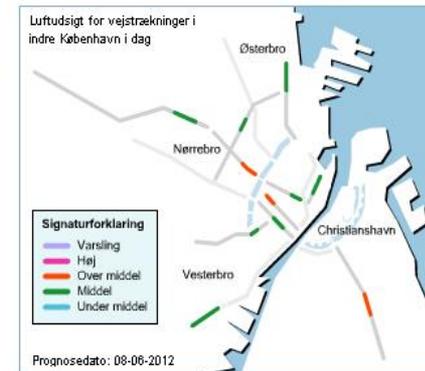
Luftudsigten er et tilbud til dig, som bor eller færdes i København. Med Luftudsigten kan du hele tiden kan være opdateret med den nuværende og kommende luftkvalitet i byen og eventuelt tage dine forholdsregler.

Brug luftudsigten i din hverdag

Fredag Den 8-6-2012	Middel
Lørdag Den 9-6-2012	Under middel
Søndag Den 10-6-2012	Middel

Sådan laves luftudsigten

Luftudsigten er, ligesom vejrudsigten, et forsøg på at kigge nogle dage frem i tiden. I stedet for vejr-symboler viser luftudsigten fem meldinger for forurenningen: Under middel, middel, over middel.



Vælg vejstrækning



External costs of air pollution

- › **External costs are defined as the costs that are attributed to others and not accounted for (welfare economic costs)**
- › **External costs for air pollution (excl. CO₂) are related to health effects and estimated based on the "impact pathway" method (EVA-system)**

EVA – Economic Valuation of Air pollution

- › Emissions sources
- › Concentration (DEHM) and (UBM) and population exposure
- Health effects based on exposure–response relations
- › External costs based on pricing of health effects
- › Output:
 - › Health effects
 - › External costs
 - › Unit costs
- › Applications:
 - › Assessments, cost-benefit

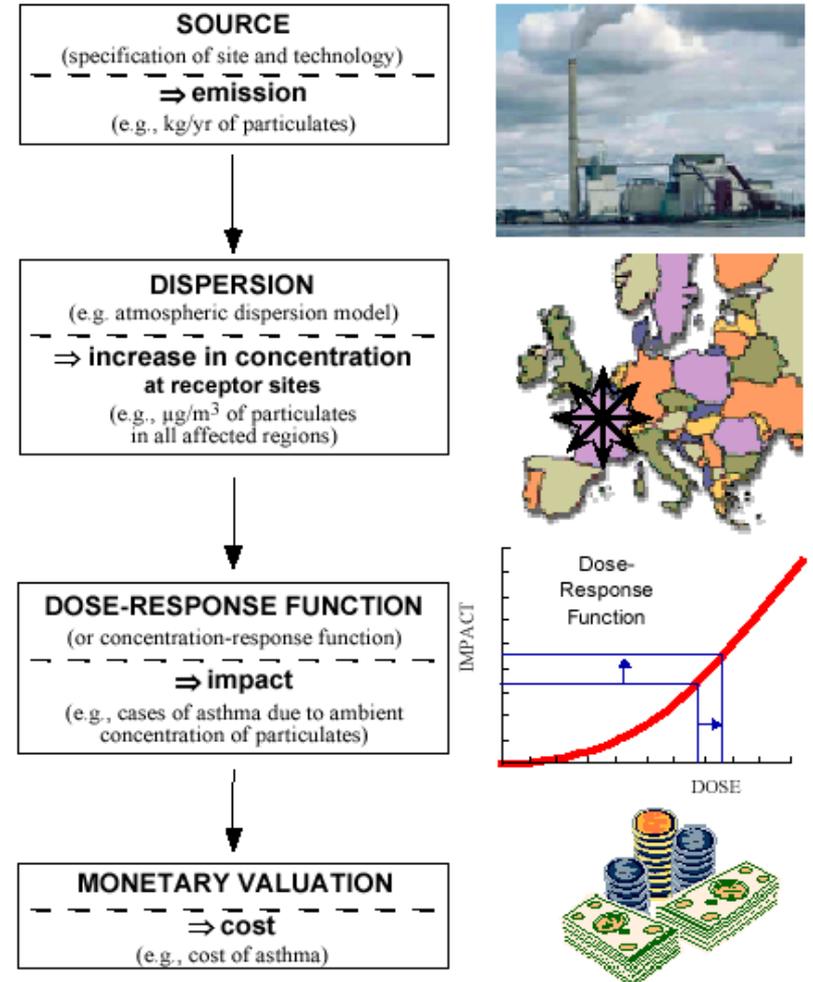
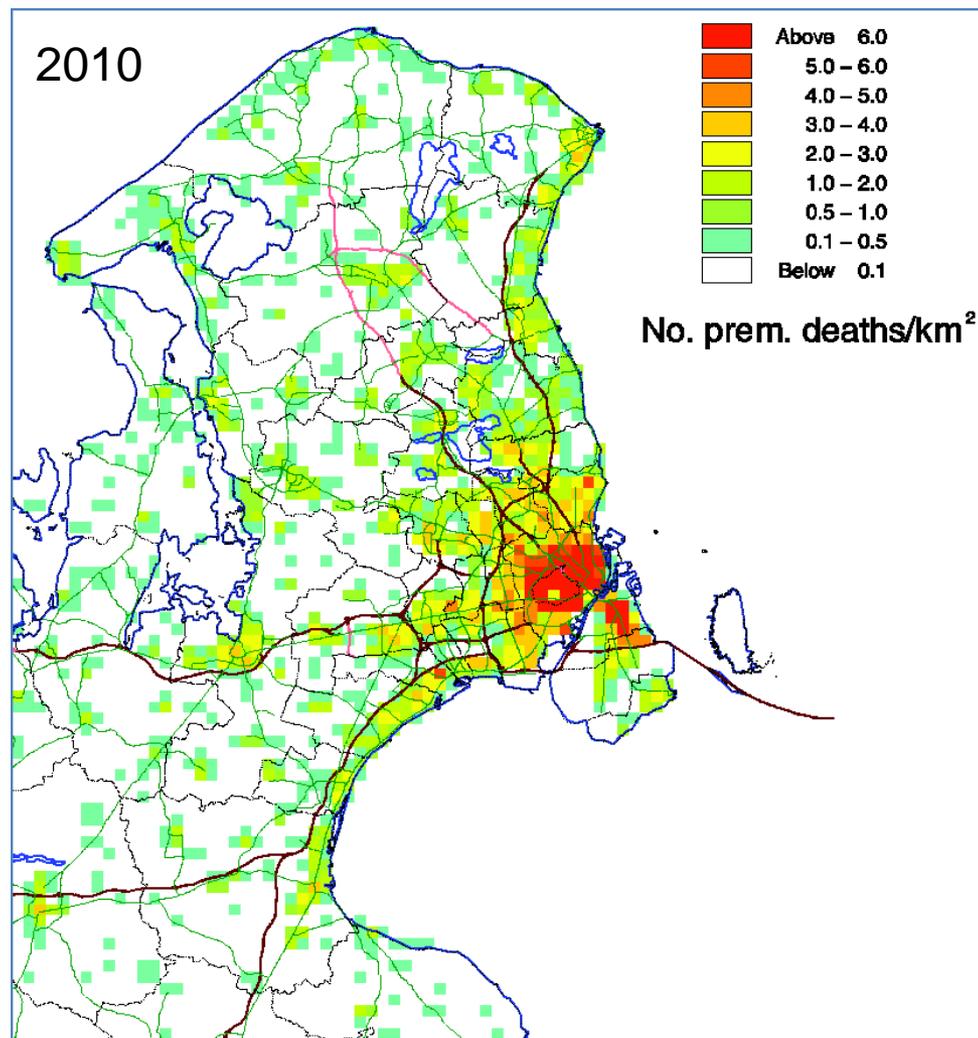


Figure 2: The impact pathway approach.

(Brandt et al. 2011)

Premature deaths in Copenhagen region

- > total of ~1500 premature deaths for the whole area due to all domestic and foreign emissions or about DDK 12 billion per year
- > ~540 in inner city (Municipalities of Copenhagen and Frederiksberg) or about DDK 4 billion per year
- > local emissions in Copenhagen and Frederiksberg contribute only about 11%





Impact assessment of policy measures

- › **Impact assessment of different policy measures on emissions and air quality levels**
 - › **urban planning**
 - › **transportation schemes**



Impact assessment of urban planning

- › **Impacts of land-use changes (UBM)**
 - › moving industrial areas to outskirts of cities
 - › optimal location of new industry given different location alternatives
 - › urban sprawl versus densification
- › **Detailed studies of single or many streets (OSPM)**
 - › impacts to emissions and air quality of changes in traffic (total flow, vehicle distribution, travel speed)
 - › changes in the street geometry like street width or larger changes to the building facade e.g. openings or change in building height

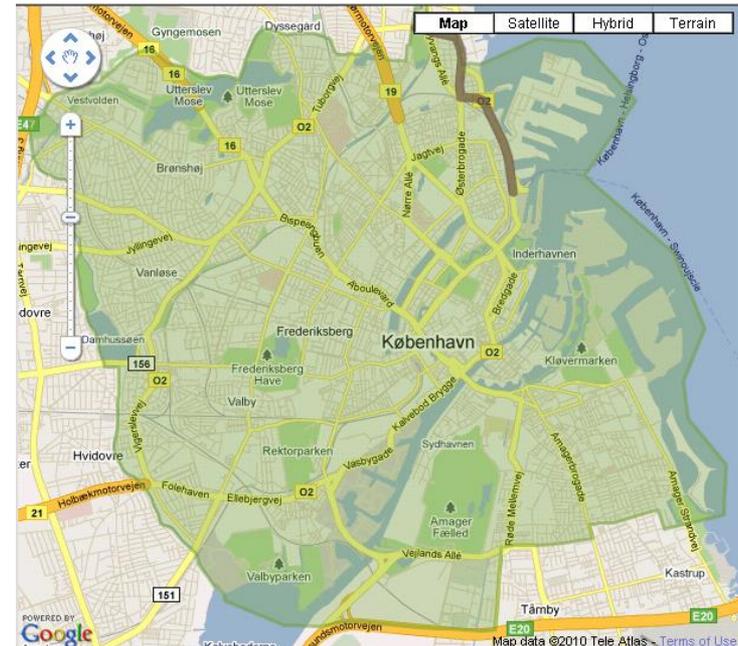


Impact assessment of transportation schemes

- › **Road network and associated traffic (e.g. based on traffic modelling)**
- › **Traffic (total flow, vehicle distribution, travel speed) in an existing road network**
- › **Traffic due to policy measures such as toll ring, road pricing or other traffic management schemes**
- › **Vehicle emissions due to:**
 - › **dieselisation of the vehicle fleet**
 - › **Low Emission Zone (LEZ) that ban older vehicles (older emission classes) to enter a zone**
 - › **scenarios for introduction of electric vehicles**
 - › **etc.**

Existing Low Emission Zone

- › **Particle filters on diesel-powered heavy-duty vehicles > 3½ ton**
 - › Euro II and older by September 1, 2008 (vehicles ≤ 2001)
 - › Euro III and older by July 1, 2010 (vehicles ≤ 2006)
- › **Established in Copenhagen in Sept. 2008)**
- › **Particle filters in average assumed to reduce exhaust PM by 80%**
- › **Impacted assessed with UBM-OSPM and regional measurements**



Low emission zone in Copenhagen, equal to municipal border

◆ Other cities

- **Aalborg (Feb, 2009)**
- **Odense (Jul, 2010)**
- **Aarhus (Sep, 2010)**



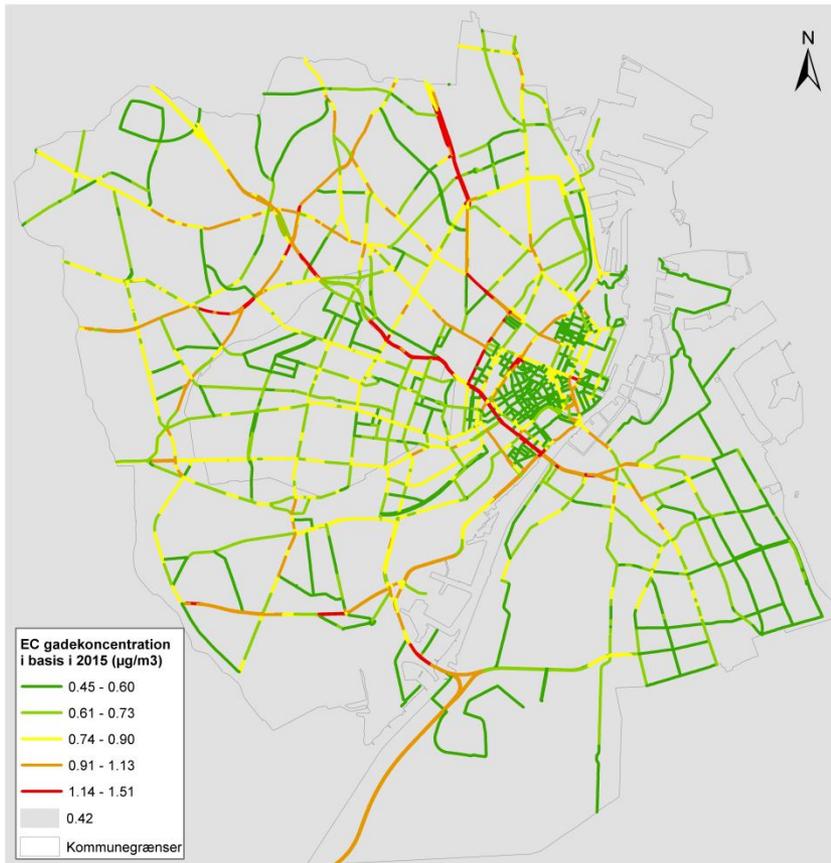
Impacts of LEZ in Copenhagen

- › **PM exhaust emission from HDT is reduced by 60% in 2010 corresponding to 16% for all traffic (HCAB) (due to shift to EEV/Euro5 and re-profit of DPF on \leq Euro 3)**
- › **LEZ reduces PM_{10} street concentrations with $0.2 \mu\text{g}/\text{m}^3$ (1%) and $PM_{2.5}$ also by $0.2 \mu\text{g}/\text{m}^3$ (1.5%) modest change due to significant non-exhaust and regional contribution**
- › **NO_x reduction of about 25% due to a partly shift towards Euro 5 vehicles instead of equipping all heavy-duty vehicles with particle filters (Euro 3 or older)**
- › **Total NO_x emission reduced 8% in 2010**
- › **No. of exceedances of the NO_2 limit value in 2010 47 to 29 (out of 138 streets)**

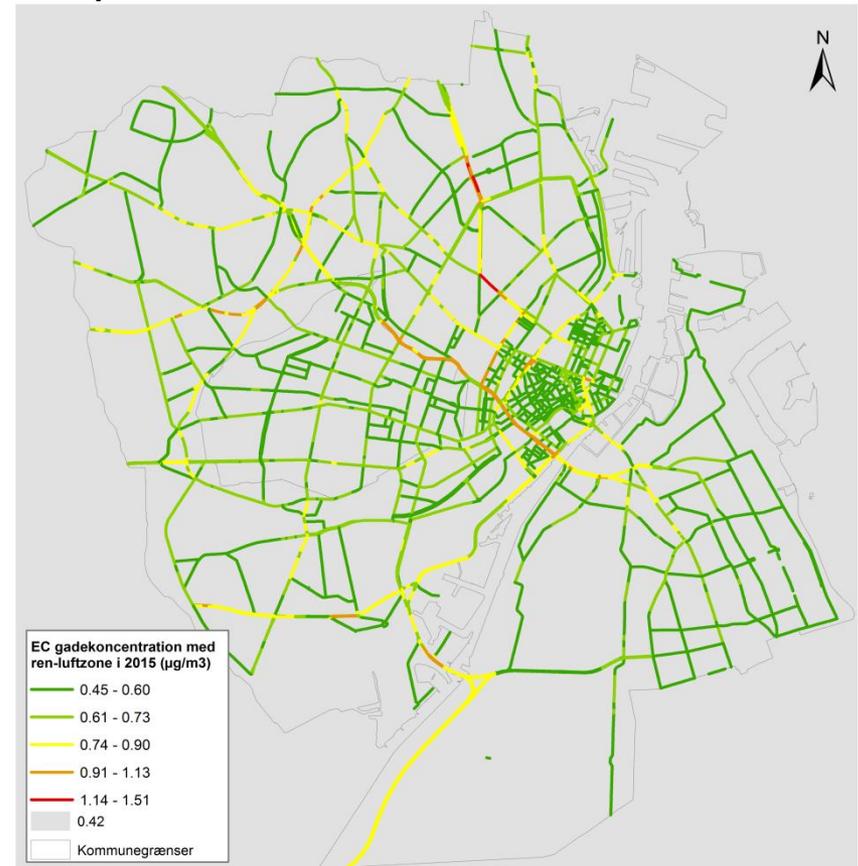
Impacts of proposed LEZ to EC concentrations in CPH

UBM/OSPM/AirGIS

Reference in 2015



Proposed Berlin scenario in 2015



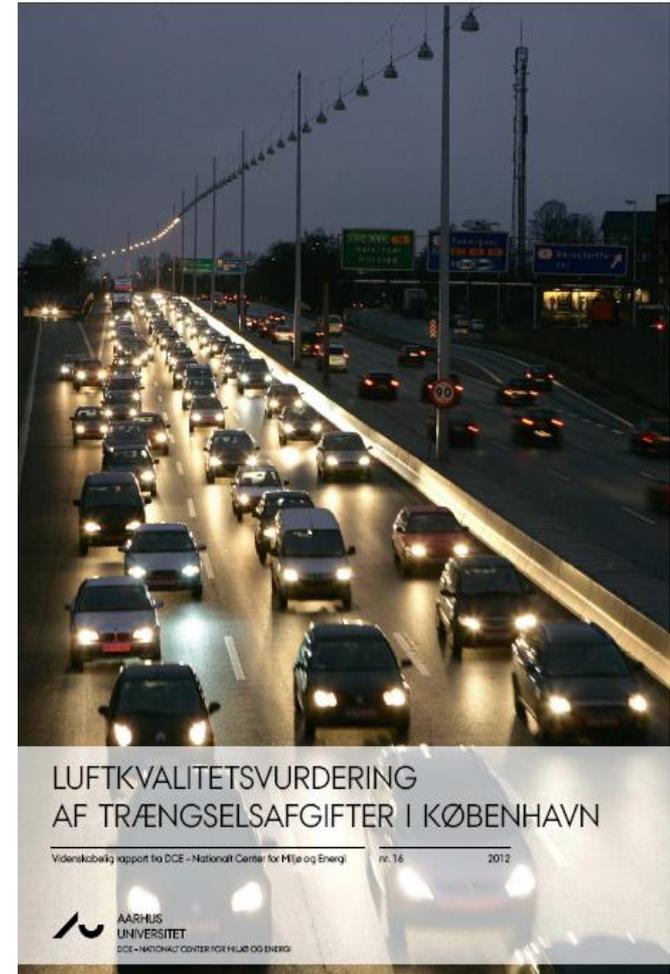
(Jensen & Ketzel 2014)

Berlin scenario: Diesel-dreven passenger cars and vans \leq Euro 3 and petrol-dreven passenger cars and vans \leq Euro 0 are banned in LEZ

Proposed toll ring in Copenhagen

◆ Congestion charging

- impact assessment showed reduction in traffic by 19% and in NO_x emissions by 10%
- reduction in No. of NO_2 exceedances from 11 to 6 in 2016 (out of 138 streets)
- proposal turned down due to opposition



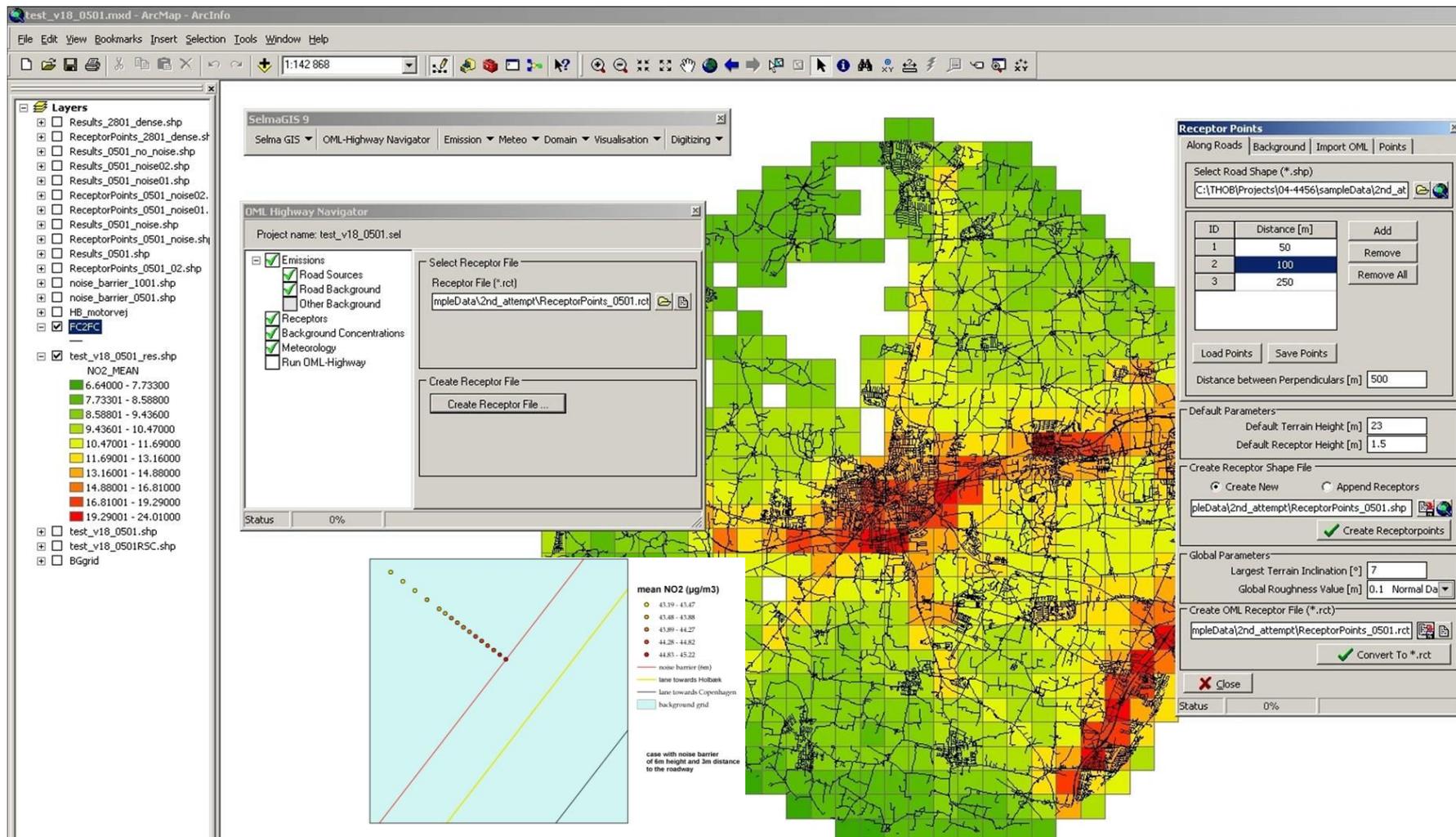


Thank you for
your attention

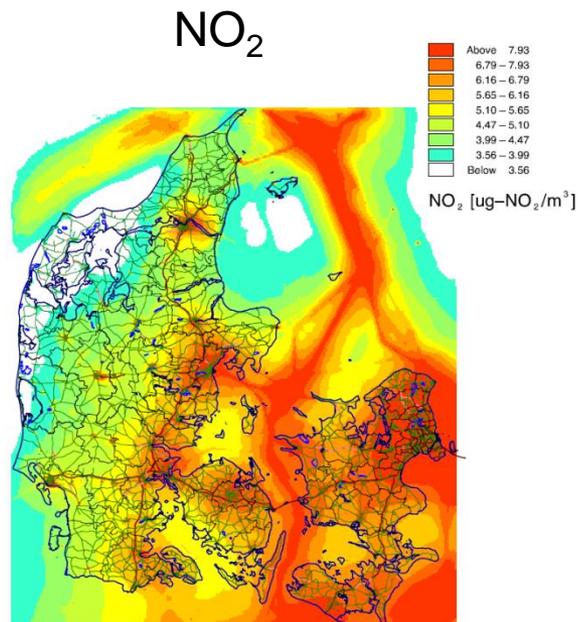


Supplementary slides

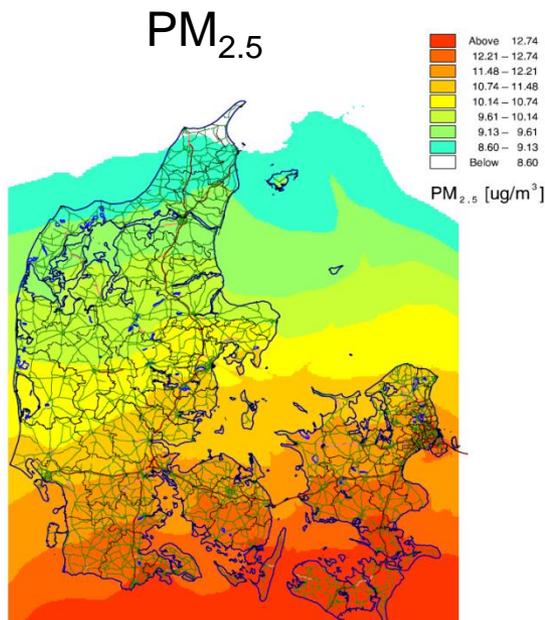
for Highways in a GIS Environment



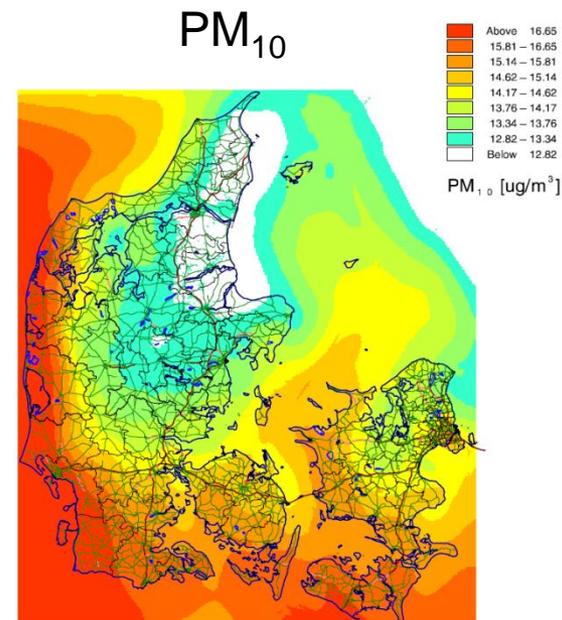
Urban background variations



- › **Traffic sources and ships emissions clearly visible**

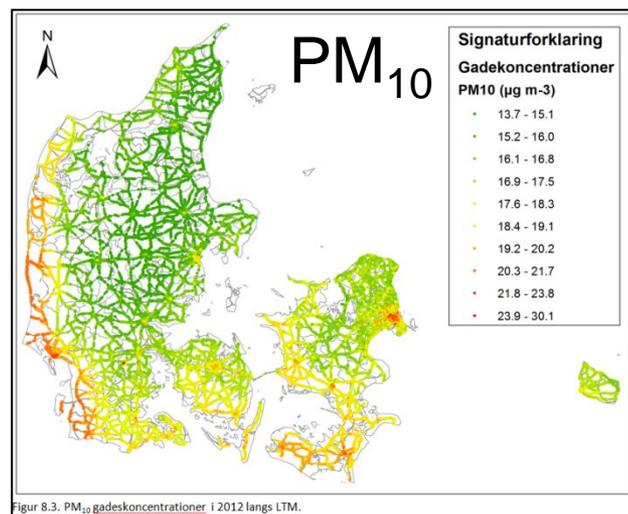
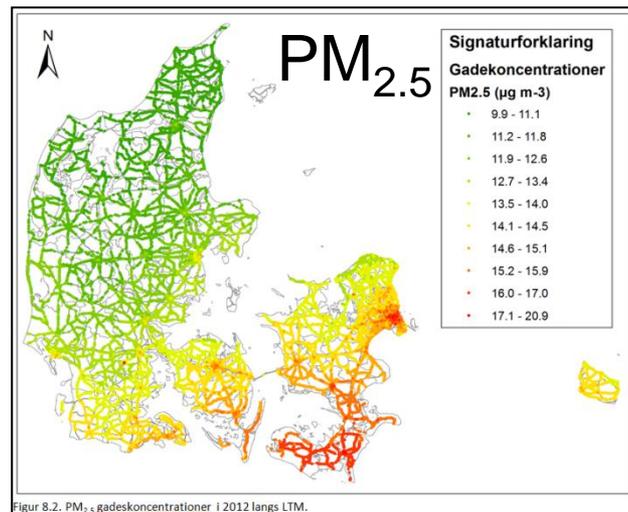
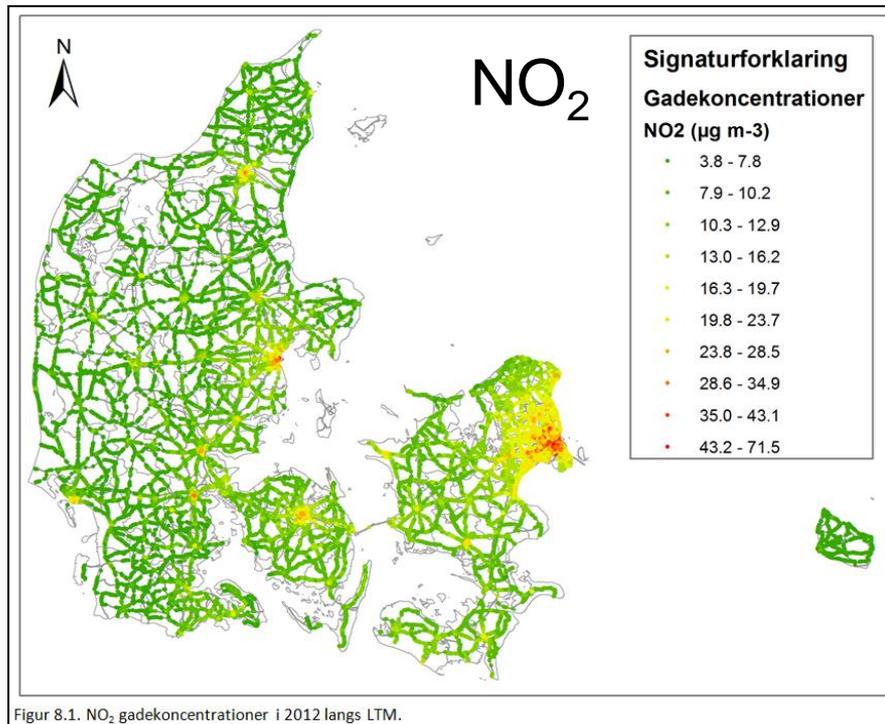


- › **Dominated by long-rang and local sources hardly visible. Gradient from south.**



- › **Dominated by long-rang and local sources hardly visible. Sea salt visible.**

Geografic variation at address level





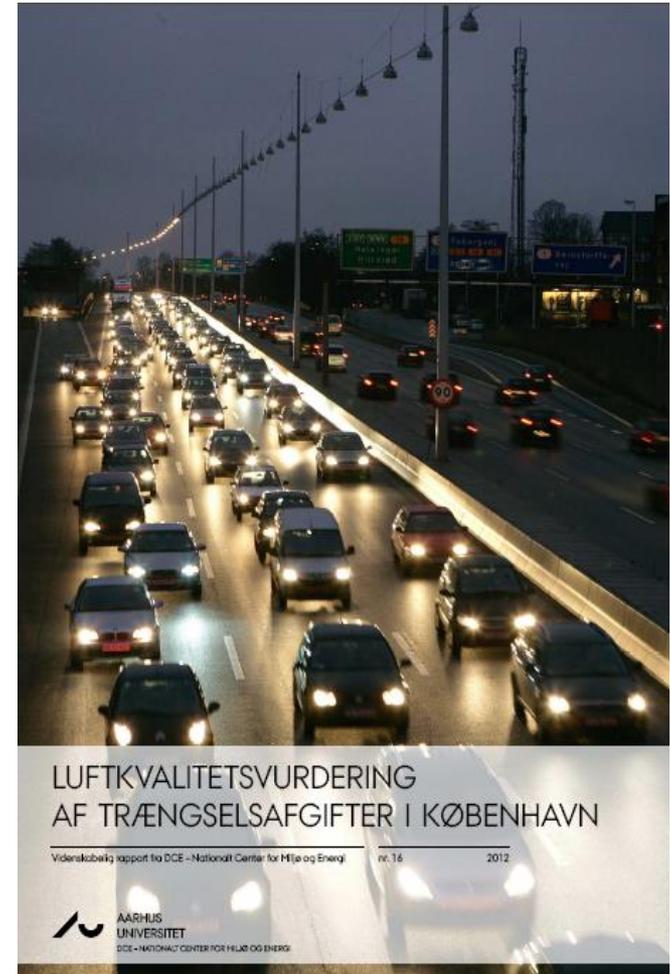
Scenarios to reduce NO₂ exceedances in 2010

Policy measures	Content	Type of measure	Number of exceedances of NO ₂ limit value in 2010	List of priority according to number of exceedances of NO ₂ limit value in 2010	List of priority according to NOx emissions in environmental zone	List of priority according to directly emitted NO _x emissions in environmental zone
German environmental zone regulation in Copenhagen	From January 1, 2010 all petrol-powered vehicles must be at least Euro 1 and all diesel-powered vehicles must be at least Euro 4 (or Euro 3 with particle filter).	Emission requirements in environmental zone	10	1-2	1	2
NOx reduction equipment on heavy-duty vehicles	NOx reduction equipment (Selective Catalytic Reduction) on all diesel-powered trucks and buses with Euro 3 or older.	Emission requirements in environmental zone	10	1-2	2	1
Toll ring	Toll ring in Copenhagen	Economic	25	3	4	5
Road pricing	Road pricing as part of national measure	Economic	28	4	5	6
Accelerated introduction of new emission standards for diesel-powered passenger cars and vans	Accelerated introduction of new emission standards for diesel-powered passenger cars and vans (two years earlier for Euro 6)	Emission requirements in environmental zone	10 (i 2015)	5	7	4
Ban on petrol-powered passenger cars without catalytic converters	Ban on all pre-Euro 1 petrol-powered passenger cars.	Emission requirements in environmental zone	30	6	3	8
Introduction of low emission vehicles like electric cars, hydrogen fuel cell cars, hybrid cars etc.	Newly registered passenger cars are assumed to be low emission vehicles with no local emissions (electric cars).	Technology/Planning	33	7	6	3
Traffic management	Harbour tunnel, Metro City Ring, commuter plans, traffic calming in Copenhagen.	Planning	44	8	8	7
Transfer car transportation to public transportation	Upgrade and expand public transportation in combination with restrictions on car transportation.	Planning	n.a.	n.a.	n.a.	n.a.

Compliance for NO₂ in 2015?

◆ Congestion charging

- part of government agreement of new minority government in 2011
- impact assessment showed reduction in traffic by 19% and in NO_x emissions by 10%
- reduction in No. of NO₂ exceedances from 11 to 6 in 2016 (out of 138)
- proposal turned down due to opposition





Overall control strategies

- › **Permanent control**
 - › permanent control measures to ensure good air quality at all times
- › **Emergency control**
 - › emergency control measures when variations in meteorological conditions or other reasons cause there to be a concern of a serious deterioration in air quality
 - › e.g. burn ban for wood stoves in US or temporary closing down of factories in Beijing during Olympic games



Overall abatement strategies

- > **Emission reduction**
- > **Dilution**
- > **Separation between source and receptor**
- > **Cleaning the environment**



Different types of abatement measures for road transport

- > **Technology**
 - > end-of-pipe, cleaner vehicle and fuel technology, in-use control
- > **Economic instruments**
 - > toll ring, road pricing, fuel and vehicle taxes
- > **Planning**
 - > urban planning, traffic planning, air quality planning
- > **Behaviour**
 - > information campaigns e.g. promoting bicycling



X

> X