IMPACT ON LOCAL AIR QUALITY OF THE DANISH LANDWORKS IN THE FIXED LINK ACROSS ØRESUND

Ruwim Berkowicz, Jes Fenger, Henrik Gudmundsson, Elisabetta Vignati and Morten Wagner.

National Environmental Research Institute
Frederiksborgvej 399, DK-4000 Roskilde, Denmark.

ABSTRACT

The combined bridge and tunnel link between Sweden and Denmark (the Øresund Link) and the related land constructions are expected to be in operation around the turn of the century. This new link across the Øresund and the island Amager may result in significant changes in traffic pattern and traffic intensity - and therefore changes in air quality in some areas can not be excluded.

An investigation initiated in 1994 on the Danish side of the link comprises monitoring of present air pollution at the Airport Motorway and model evaluations of future pollution levels at the motorway and in six street canyons. For all locations the pollution levels are calculated for the present situation and for scenarios for the years 2000 and 2010 both with and without the fixed link. For the future scenarios an expected development of vehicle technology is taken into account. It appears that the general air quality in the area will not be worsen. Only for benzene there is a continued risk of violation of limit values; this may however be changed by planned emission restrictions.

A special situation however, may arise near the apartment buildings "Vinkelhusene". Here it has been decided to cover about 700 m of the motorway, in order to reduce noise and to avoid a barrier effect. This will result in increased pollution levels near the tunnel exits.

All calculations are performed with dispersion models developed at the National Environmental Research Institute and are based on traffic scenarios from a traffic model developed by Anders Nyvig Ltd.

1 THE FIXED ØRESUND LINK

In 1991 the Danish Parliament passed a bill on the establishment of a fixed link between Denmark and Sweden across the Øresund. The link, which comprises a two lane railway track and a two by two lane motorway, is divided in three parts:

- Land constructions in Denmark, managed by *The Danish Landworks for the Fixed Link across Øresund*
- Land constructions in Sweden, managed by *The Swedish Landworks for the Fixed Link across Øresund*
- The coast to coast connection, managed by the *Øresund Fixed Link Coast to Coast Project*, which is owned by the two national companies.

Due to the existing flight path from Copenhagen Airport in Kastrup, the link is planned with a nearly 4 kilometre tunnel from Amager towards the very flat island Saltholm. Next follows an artificial island with a low-level bridge south of Saltholm. Finally an elevated bridge for traversing is connected to Sweden.

On the Danish side, the tunnel ends at an artificial peninsula north of the airport, from which the railway and the motorway are carried across Amager. The railway is connected to the Central Station in Copenhagen, the motorway is connected to an existing motorway system taking the through traffic south of the City of Copenhagen. Most of the land based constructions are open, but often low-level and surrounded by baffle walls. In a residential area however, about 700 m will be covered - partly in order not to disturb the local infrastructure, partly to reduce noise nuisance. This will not influence the total emissions, but they will be concentrated at the tunnel exits.

2 EARLIER INVESTIGATIONS

A project of this magnitude can have impact on the environment in many ways. Concerning air pollution the situation is complicated, because the effects depend not only upon the constructions as such, but also upon how much the link will be used. Further, impacts on existing traffic forms and changes in existing traffic movements e.g. due to the establishment of the connecting road systems must be taken into account. Finally, technological developments can be expected, and although they may not be directly connected to the project, they may influence the total outcome. Therefore evaluations of air pollution impacts involve elements of prognosis, which introduce uncertainties larger than in the calculations proper.

So far Danish investigations of air pollution effects of the Øresund link have been based on an assumed traffic volume across the link of about 8-10,000 vehicles per day (1). Local air pollution levels were estimated for 7 representative streets. The method applied for calculation of pollution levels was very crude, but it was suggested that in the future air pollution guidelines (but not binding limit values) may be exceeded both with and without the fixed link.

Swedish investigations (2) have been more detailed and comprise dispersion modelling for the Øresund region assuming daily traffic on the link of 30,000. Pollution levels will increase at the connecting roads in Malmø, but not above existing Swedish limit values. The investigations do not give information on local Danish levels.

3 MEASUREMENTS OF LOCAL AIR QUALITY

Air pollution in the Greater Copenhagen area is currently studied as a part of The Danish Air Quality Monitoring Programme (3) in collaboration with the EPA of the City of Copenhagen. An earlier investigation (4) showed that at Amager the airport only contributes significantly to air pollution in the terminal area and its immediate surroundings.

The Airport motorway is expected to carry most of the traffic connected with the new link and land constructions. In an attempt to determine the influence of the present traffic on local air quality and to provide experimental basis for evaluation of the future changes due to the planned fixed link and the land constructions in Denmark, the Copenhagen-EPA established

two measuring stations close to this motorway. One station was placed some 40 m North of the motorway and the other station some 15 m South of the motorway (5).

The highest pollution levels are expected on the station that is downwind from the motorway, and indeed, the Southern station exhibits higher NO_x-levels than the Northern station, when the winds are Northerly. A corresponding maximum on the Northern station for winds from South is, however, practically absent. The reason may be that the station was placed to far from the motorway to capture the influence of the local traffic. Similar NO_x-levels are observed at a station placed on a roof of 20 m high building in Copenhagen, indicating that the pollution levels observed at the motorway stations may be partly due to long range transport of pollutants, and that the local influence is small. The measurements thus show that the contribution to NO_x pollution levels from the present traffic on the Airport motorway is very modest and comparable with the urban background levels in Copenhagen.

Similar behaviour is expected for other primary pollutants, as e.g. CO and many hydrocarbons. In measurements of NO_2 the contribution from the highway cannot be identified. The reason is that the concentration of NO_2, which is a secondary pollutant, is largely determined by oxidation of NO by O_3, whereas the local formation is small.

4 TRAFFIC STATISTICS AND PROGNOSIS

The investigation has comprised the future motorway and 6 streets at Amager. The emission prognoses comprised 4 scenarios, which are compared with the situation in 1992:

- year 2000 with both land- and coast to coast constructions (only for a single street)
- year 2010 without new constructions
- year 2010 with land constructions only
- year 2010 with both land- and coast to coast constructions

Air quality calculations are based on actual and projected traffic data for streets, which are selected by the following criteria: Moderate to high level of traffic today, moderate to poor air quality according to planning indicators, and moderate to large expected changes in traffic volumes due to the fixed link and the motorway.

Traffic data for each street has been distributed over 24 hours and split into three groups: all cars below 3.5 t, trucks above 3.5 t and buses. Only traffic during daytime (600-1800 h) is counted, therefore 24-hourly distributions for light and heavy traffic have been estimated, using traffic distribution data from the two central harbour bridges in Copenhagen as a proxy. Comparisons for only 6-18 periods of traffic show a good correlation. In the future scenarios no changes in the 24-hour distribution of traffic or the percentage of heavy traffic are assumed.

The traffic in the scenarios is calculated on the basis of the HTM (Copenhagen traffic model) developed by Anders Nyvig Ltd. (6). It was originally a strategic model used for evaluating traffic investments, but it has later been extended i.a. in order to give a better description of traffic in individual streets. The traffic statistics are converted into emissions with the model BILEMIS (7), where the cars are distributed on various types, fuels and age groups. The model further takes expected developments in legislation, technology and driving pattern into account.

5 DISPERSION MODELLING

The Operational Street Pollution Model (OSPM) has previously been successfully tested against measurements (8). It simulates the hourly mean pollution in streets using actual meteorological observations and emission inventories based on traffic statistics. A special dispersion model was developed to describe the situation, where the motorway is conducted in a tunnel (9). The dispersion calculations were carried out on the basis of meteorological data from 1994, measured at the roof station at the H.C.Ørsted Institute, where also the background pollution was monitored.

6 RESULTS FOR STREET CANYONS

In general, traffic volumes will be higher in the future scenarios than in 1992 (Figure 1, upper plot). The land constructions however, will direct traffic away from some of the streets, while others appear not to be relieved. The traffic from the coast to coast connection will mainly follow the major arteries and thus not significantly increase traffic on the local street network on Amager. The emissions (Figure 1, lower plots) will be lower in the future scenarios, than the increase in traffic indicates, due to improved technology and tighter regulations.

By and large the air pollution levels (Figures 2 and 3) will follow the emissions, i.e. with generally lower levels in the future scenarios. The changes for NO_2, however are markedly smaller than for the other pollutants, since NO_2 is mostly formed by oxidation of NO with ozone and not emitted directly.

The changes in air quality, which can be ascribed to the fixed link are for all the streets marginal. The calculated levels are by and large the same as can be expected for a situation corresponding to the general development in traffic up to year 2010 *without* the link and the related land constructions. At a distance of 50 m from the open motorway the levels will for all pollutants be close to the background levels. The main reason being the open surroundings and the generally good dispersion conditions.

The calculated air quality has been compared with Danish limit values for NO_2 and CO (98%-fractiles of 1 h. averages and yearly averages). Further an often used yearly average for benzene of 10 $\mu g/m^3$ has been applied. For 1992 the long term limit for NO_2 (50 $\mu g/m^3$) is marginally exceeded at a single street, but at none of the streets are short term limits for NO_2 or CO exceeded. For the future scenarios no exceeding for NO_2 or CO are indicated. For benzene however, the 10 $\mu g/m^3$ yearly average is touched or exceeded at nearly all streets in 1992, and this persists in the future scenarios. Exceeding of the benzene level has been detected in the Danish Urban Monitoring Programme, where annual averages of 19 $\mu g/m^3$ were reached at Jagtvej in Copenhagen (10).

The basic uncertainty in the results are due to uncertainty in the traffic and emission prognoses. The assumption of a constant background contribution is probably pessimistic and may lead to an overestimation of the levels.

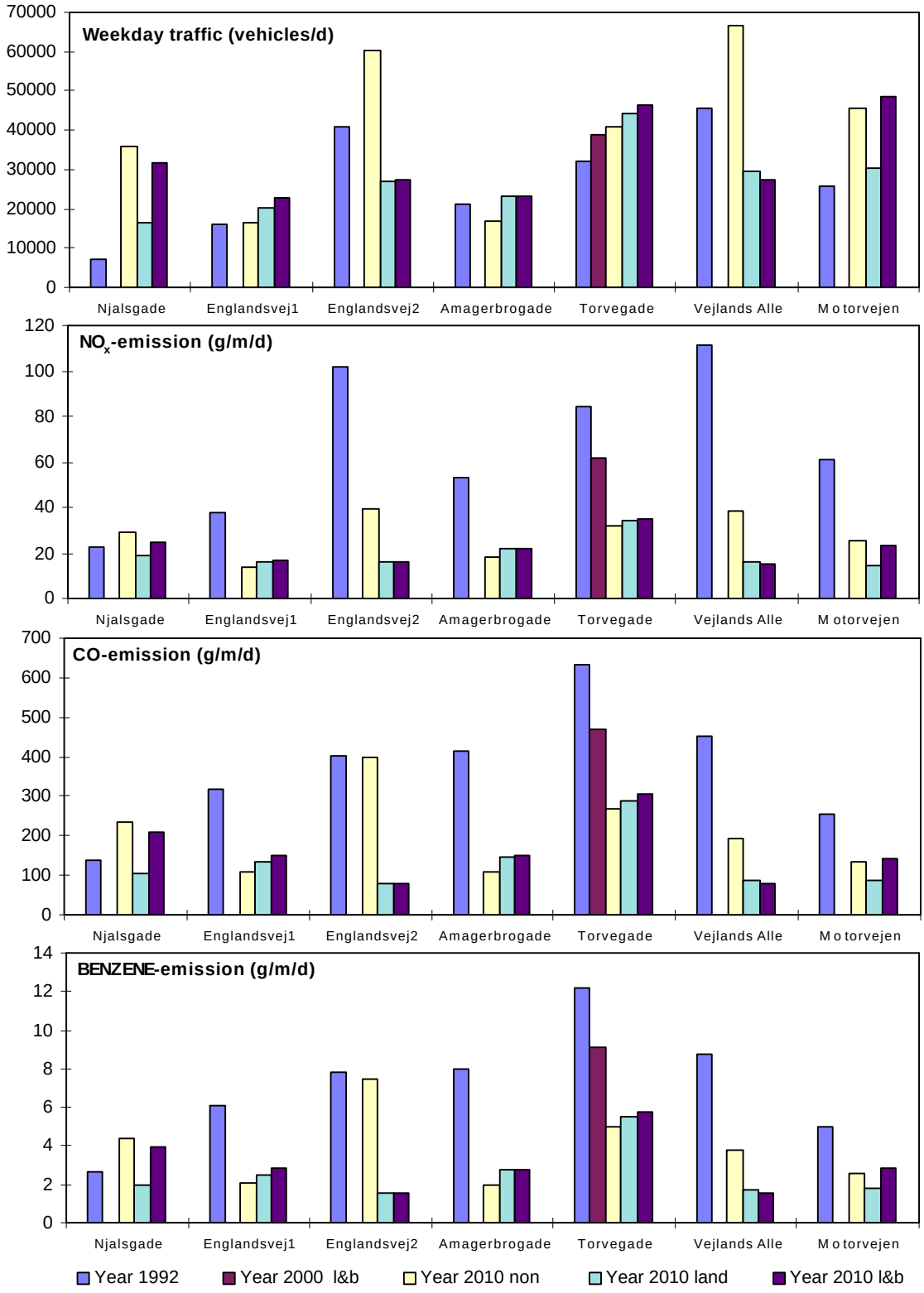

Figure 1. Weekday traffic and daily emissions of NO_x, CO and benzene in the 7 investigated streets. The scenario for year 2000 with the full fixed link is only used for "Torvegade".

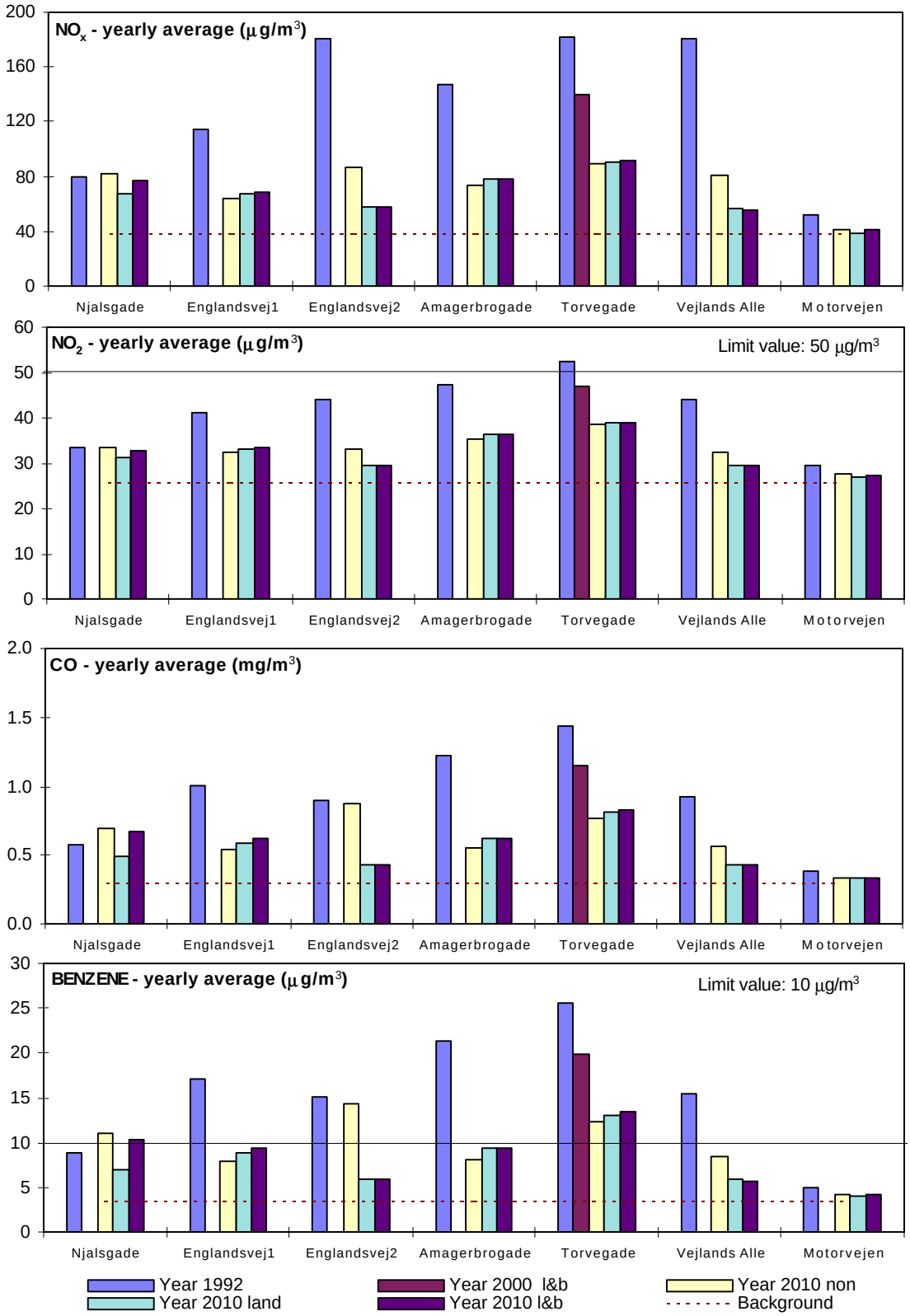

Figure 2. Yearly averages of calculated pollution levels corresponding to the emissions shown in figure 1. For comparison, background concentrations in Copenhagen 1994 (dotted lines) and limit values for NO_2 and benzene (full lines) are indicated.

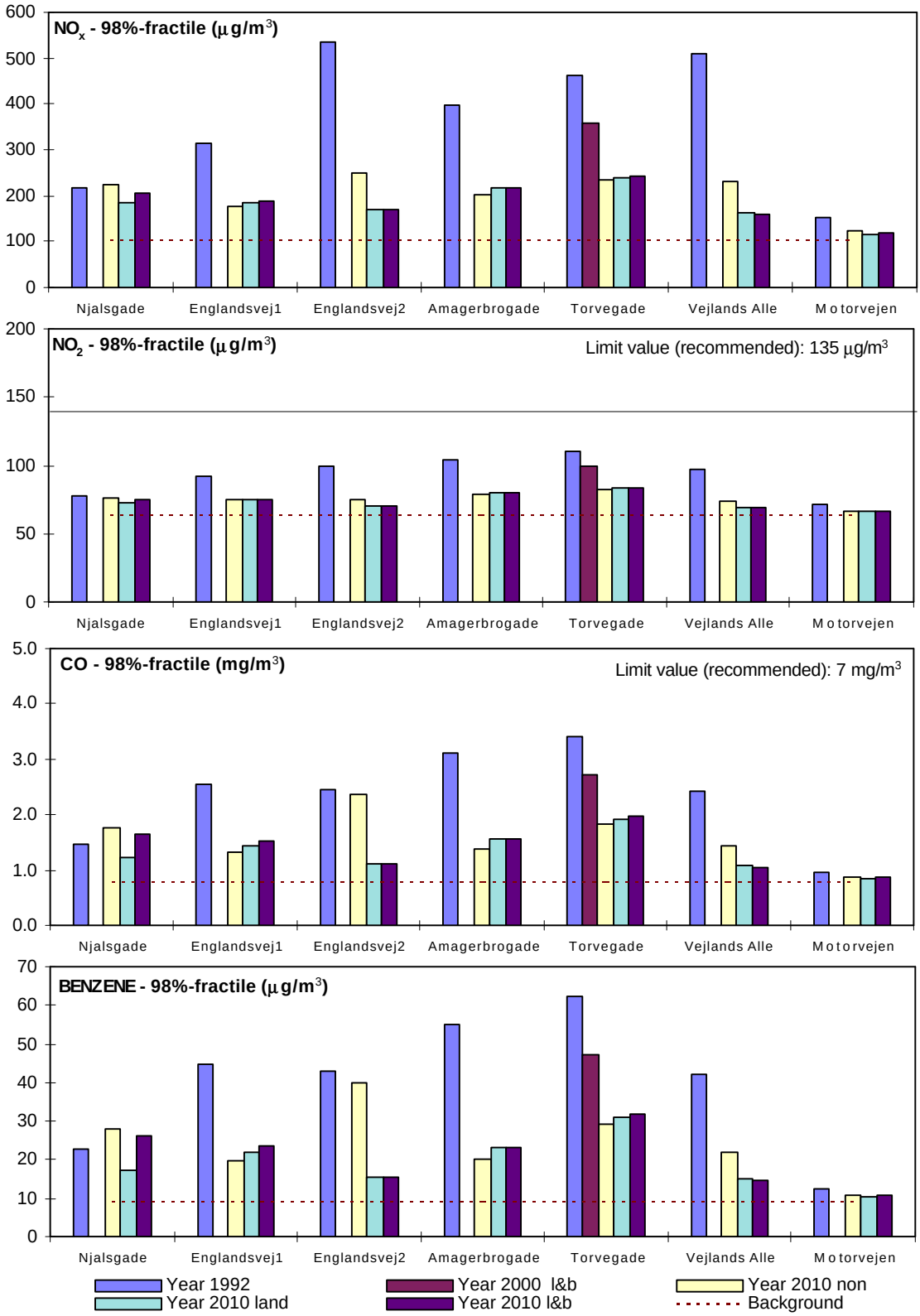

Figure 3. 98%-fractiles of the calculated 1-hour averages of air pollution corresponding to the emissions shown in figure 1. For comparison (as in figure 2) background concentrations and limit values are indicated.

7 THE TUNNEL AT "VINKELHUSENE"

The new motorway across Amager will generally be 7 m below level. At the "Vinkelhusene" it will further be covered at a length of about 700 m thus creating a tunnel with separate tubes with one way traffic. Under normal conditions the tunnel will be passively ventilated i.e. the traffic itself will act as pistons to remove the emitted pollutants. Only in case of emergency an additional ventilation will be necessary.

This tunnel and its connection to a crossroad (Englandsvej) constitute a system with complex pollution release conditions. Scenarios for year 2000 and 2010 were investigated with the special dispersion model (9). In both cases it was assumed that the motorway *with* tunnel as well as other land constructions and the coast to coast link are in operation. Calculations have shown that pollution levels in the surroundings of the motorway will in general be low, but that they may rise up to 117% near the tunnel ports compared to a situation without the tunnel. On the other hand, a 36% reduction of the pollution levels on the covered area can be expected (Figure 4). Exceeding of the limit value for benzene must be expected even in year 2000, but only in the immediate vicinity of the tunnel ports (Figure 5). In the most of the area the concentrations of benzene are expected not to exceed the background value by more than 10%.

8 CONCLUSION

The establishment of a coast to coast connection across Øresund and the related land constructions will change the traffic pattern and consequently also the air pollution, especially at the island Amager. Further the pollution levels will be influenced by anticipated technical developments and legislations.

The described investigations indicate however, that - under the given assumptions - the fixed link will not cause a general deterioration of the air quality at Amager. In some streets the conditions may even be improved due to a reduced traffic intensity. In other cases an increase in traffic will presumably be compensated by technological development. For benzene the present violation of limit values will continue unless planned emission restrictions are carried out.

The tunnel at the apartment buildings "Vinkelhusene" will in itself not change the total emissions, but will concentrate them at the tunnel exits, thus creating locally elevated pollution levels.

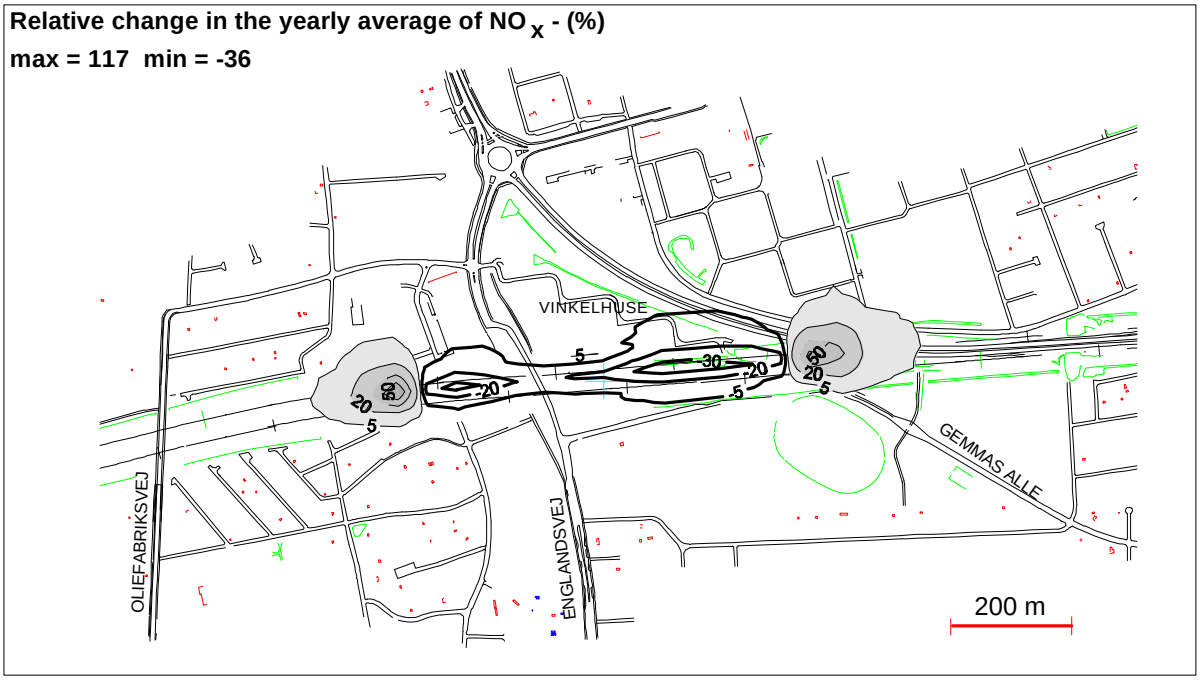

Figure 4. The relative change in the yearly average of NO_x-concentrations due to the construction of the tunnel at "Vinkelhusene". The shaded areas indicate where the pollution level will increase.

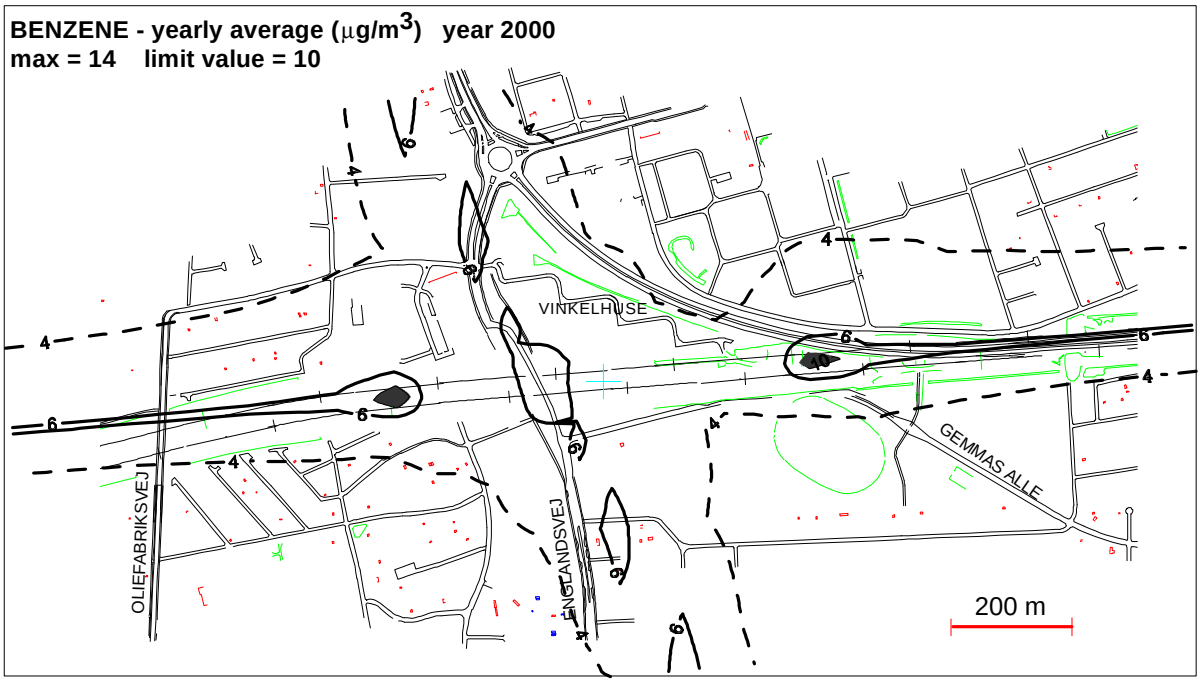

Figure 5. Yearly averages of the calculated concentration of benzene in the year 2000 with tunnel. The dashed isolines show the area where the concentrations are at most 10% above the background value. The shaded areas indicate where the value 10 µg/m^3 is exceeded.

REFERENCES

Some of the references are to reports in Danish and Swedish. They are listed here with the original titles in brackets.

1 Ministry of traffic, Environment Oresund. The fixed link Copenhagen-Malmo (Miljø Øresund 1991. Den faste forbindelse København-Malmø). Ministry of Traffic, Copenhagen, 1991, 125 p. Later in 1991 a slightly revised version of the air pollution calculations were presented in an internal note.

2 Oresundskonsortiet, Evaluation of environmental consequences of the Oresund Link (Miljokonsekvensbeskrivning for Oresunds forbindelsen) SVEDAD, 1992, 159 p. with enclosures. Ch.11 concerning air pollution has appeared in a revised version Dec. 1992.

3 K. Kemp, F. Palmgren and O.H. Mancher, The Danish Air Quality Monitoring Programme. Annual Report for 1993. NERI, Technical Report No.113. 1994. National Environmental Research Institute, Roskilde, Denmark. 79 p.

4 J. Fenger, R.Berkowicz, A.B.Jensen, P.A.Nielsen, T.Nielsen, K.Pedersen, K.Pilegaard, L.Stenfalk. Air Quality Investigations at the Copenhagen Airport 1988-1989 (Luftforureningsundersøgelser ved Københavns Lufthavn 1988-89). Copenhagen Airports Authorities, Copenhagen, 1990. 71 p.

5 Copenhagen EPA (Miljøkontrollen i København), Measurements of air pollution at 6, Pollux Alle and 11-13, Orions Alle (Måling af luftforurening ved Pollux Alle Nr.6 og Orions Alle Nr.11-13). Copenhagen EPA, Copenhagen, 1995. 19 pp. with appendices.

6 Anders Nyvig Ltd., Traffic calculations for the Danish landworks in the fixed link across Øresund, Road traffic (Trafikberegninger for Øresundsforbindelsens danske landanlæg, vejtrafik). Copenhagen, 1996. var. pag.

7 S.C.Sorenson, An emission prognoses for Denmark 1990-2010 (En emissionsprognose for Danmark 1990-2010). Lundtofte, Technical University of Denmark, 1993. 129 pp.

8 R. Berkowicz, O. Hertel, N.N. Sørensen and J.A. Michelsen, Modelling Air Pollution from Traffic in Urban Areas. IMA Conference on Flow and Dispersion Through Groups of Obstacles, 28-30 March, 1994, University of Cambridge, UK. Cambridge University Press, in press.

9 R. Berkowicz, A model for dispersion of air pollution from a motorway with an associated tunnel. To be published as a technical report from The National Environmental Research Institute, Denmark.

10 F. Palmgren, A.B. Hansen, R. Berkowicz, A.H. Egeløv, Volatile organic air pollution from road traffic. Trafikdage på AUC, Aalborg, 21-22 August 1995.