Proposal for a strategy to limit noise from road traffic

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1 Summary

Background

In May 2002, the Government set up a cross-ministerial Road-Noise Group with the objective of preparing a proposal for a strategy to limit noise from road traffic. In the Strategy, an overall assessment of the potential of various tools is to be established and the possibility of achieving the goal of the former Government's traffic management plan, *Trafik 2005*, from 1993 to limit noise from road traffic to be emphasised. The Road-Noise Group's terms of reference are attached to the report as Annex 1.

According to the World Health Organisation WHO, noise from traffic can lead to annoyance and health effects such as communication difficulties, headaches, sleeping difficulties, stress, high blood pressure, a greater risk of heart disease, and hormonal effects. Noise can affect performance and children's learning ability and motivation. Noise thus has adverse health effects on people and long-term exposure can lead to actual health problems.

In connection with this, the Road-Noise Group has noted that many people in Denmark live in areas where noise from traffic is a nuisance and in some cases can lead to psychological and physical problems. About 700,000 dwellings are actually exposed to noise from traffic of more than 55dB, which is the limit value for the construction of new dwellings. Of these, about 150,000 are severely affected by road noise, i.e. exposed to more than 65 dB.

One element in the Group's work has been to ensure a good foundation for the implementation of the EU Directive on the Assessment and Management of Environmental Noise. In parallel with the work in the Road-Noise Group, the Ministry of the Environment is preparing proposals for the changes to legislation necessary to implement the new EU Noise Directive. The Directive subjects Member States to an obligation to map noise from road traffic, railways, airports, and industry for the most exposed areas by no later

than 2007. Moreover, by no later than 2008, action plans must be prepared to reduce noise and these plans must be made public.

The division of responsibilities between the state, counties and municipalities and efforts so far

The Road-Noise Strategy is based on the existing distribution of tasks between the State, counties and municipalities whereby the state is responsible for noise-related efforts on state roads and initiatives regarding the county and municipal roads are the responsibility of the relevant county or municipality.

It is estimated that 90-95 per cent of residences exposed to noise nuisance are situated alongside county and municipal roads (of this about 85 per cent are on municipal roads). It is therefore counties and municipalities that are responsible for setting priorities for any initiatives in these areas.

The Road-Noise Group has not had access to summary material that could systematically highlight the efforts of counties and municipalities to date to reduce road noise. The report does, however, provide examples of the initiatives that have taken place in counties and municipalities.

Nationwide, significant efforts have been made in the last 10 years to reduce the number of residences exposed to noise nuisance. Efforts to reduce noise have focused on the following main areas:

- noise reduction along existing roads
- noise reduction in connection with new constructions/widening of roads
- research, development and communication.

In addition, noise abatement has become an item on the EU's agenda over this period.
From 1992 to 2002, the Danish Road Directorate has continually planned and carried out noise-abatement initiatives along the existing state road network with the objective of reducing nuisance and health effects and improving the quality of life of the people who live alongside those stretches of road with the greatest noise nuisance. By the end of 2001, about DKK 212 billion had been spent on this objective.

Furthermore, significant sums are being allocated to noise reduction. in connection with the building of new state roads and extending existing state roads in urban areas. For larger extension projects, efforts will include abatement of noise from the extension work itself, as well as existing noise. An example of these efforts is the extension to the Motorring 3 motorway around Copenhagen. The remarks to the proposed construction Act (L214, adopted 27 May 2003) state that about DKK 190 million of the total construction budget of about DKK 1,800 million is expected to be spent on noise abatement, or approximately 10 per cent. Completion of this project will mean a significant reduction in the existing noise nuisance so that only a

limited number of dwellings will be exposed to more than 60 dB from the motorway after the extension. These dwellings will be offered subsidies for facade insulation.

Finally, efforts by the authorities over the past 15-20 years have concentrated on ensuring that new housing is not built with noise nuisances exceeding the recommended limit value of 55 dB. This is in accordance with provisions in the Danish Planning Act and Byggeloven ('the Building Act'), both of which have applied since the early 1980s. New residential areas cannot be laid out where noise nuisance from road traffic exceeds 55dB. For housing construction in existing urban areas, traffic noise may only be a maximum of 55dB at the façade or 30 dB indoors. In accordance with this, it is endeavoured when constructing new roads to keep to the limit value of 55dB where the road passes through large continuous urban areas.

At EU level, two directives have been adopted on requirements regarding noise emissions from vehicles and tyres respectively. In the period up to 2020, which is the Road-Noise Strategy's time horizon, this will also have a certain positive effect. These efforts have meant that the number of dwellings exposed to noise nuisance has not increased over the last few years, despite the dramatic increase in traffic. Overall, however, efforts at reducing the number of residences exposed to severe noise nuisance over the last 10 years have not been successful.

It can be therefore be stated that, within the financial scope of the period, efforts to approach the realisation of the former Government's target from 1993 and reduce the number of residences exposed to severe noise nuisance to 50,000 by 2010 were not successful.
Calculations by the Road-Noise Group of the possibilities and consequences of achieving the goal of the previous government show that the only way to achieve this goal is through extremely large investment (about DKK 7 billion), and in a manner that is not cost-effective. Against this background, the Road-Noise Group proposes that efforts against road noise are planned over a longer time horizon so that they can be organised more cost-effectively. The Road-Noise Group considers it appropriate that noise-abatement initiatives are assessed in conjunction with the preparation of noise action plans in 2007-2008 by the authorities responsible, see the Directive.

Future efforts against road noise

In this report, the Road-Noise Group provides its suggestion for the framework for the state's efforts against road noise in the coming years.

The following are presented in the report:

- An initial assessment of the extent of the social costs associated with road noise in Denmark. Attention is given to the costs in terms of health effects in the form of heart disease and high blood pressure and, as an indication of the other nuisance from road noise, a house-

price study has been carried out. The costs of health effects are calculated as DKK 0.6 – 3.4 billion annually and the costs associated with noise nuisance as DKK 5.3 billion annually. These calculations are based on most recent knowledge but it cannot be ruled out that new studies based on other assumptions would provide other results. In any case, the results have a significant amount of uncertainty attached to them.

- An analysis of tools stating the need for investment and effects. The intention has been to provide citizens and the authorities responsible with the tools to arrange cost-effective local efforts against noise, balanced against local requirements for noise abatement. The analyses demonstrate that there are good opportunities for organising efforts that provide a socio-economic benefit as the majority of the tools provide a positive socio-economic result. This also applies if we look at the various combinations of tools, the consequences of which the Road-Noise Group has gone over.
- It is assessed that there are ten tangible proposals for state initiatives in the area of noise that could be realised within the existing financial scope.

The Road-Noise Group therefore proposes that:

1. Danish efforts within the EU cooperation to tighten the requirements regarding noise emissions from vehicles and tyres should be enhanced.

2. Consumers should be informed of the possibility of changing to quieter tyres.

3. The current level of protection in connection with approved and planned traffic investment in the state road network should be retained, and this will contribute towards a significant reduction in noise levels along state roads.

4. The possibility of changing to windows with both noise-absorbing and energy-saving properties should be included in future activities for energy-efficient windows to be conducted in cooperation with the glazing sector.

5. As documentation for noise-reducing road surfaces becomes available, information activities on the effect of different types of noise-reducing road surfaces should be enhanced with a view to creating a better decision-base for road authorities to use this tool.

6. In connection with the ongoing replacement of asphalt surfacing on state roads, in light of the documentation at hand and the given construction and operating budgets, there should be assessments of whether there are grounds for using noise-reducing road surfaces.

7. The guidelines on road noise in residential areas should be updated to account for both the Road-Noise Strategy and the EU Directive on noise.

8. Municipalities and counties should be encouraged to be aware that the Danish Road Traffic Act contains provisions that the police, after consulting with counties and municipalities (road agency/road authorities), may set local speed restrictions on stretches of road with many residences exposed to noise nuisance.

9. The catalogue of the effect and cost of various tools in the Road-Noise Strategy should be distributed to municipalities and counties.

10. Stock will be taken of the ongoing noise-abatement initiatives every five years in connection with the EU Noise Directive. This will form the basis for assessing the need to adjust the Strategy.

2 Objective and background

2.1 Objective

An effective and flexible transport sector is of major importance for economic development and the welfare of the population. Modern people require a great deal of mobility in connection with work, shopping and leisure and there is a need for relevant and cost-effective transport options in connection with the consumption of goods and manufacturing.

However, these transport activities also lead to nuisance and health problems for the population in the form of traffic accidents, air pollution and noise. In both Denmark and through the EU, great efforts have been made for a number of years to reduce the two first problems in particular and good results have been achieved. Some efforts have also been made to reduce the problem of noise from traffic, particularly in respect of the residences most exposed to severe noise nuisance where noise screens have been established and grants given for noise insulation and in connection with new constructions/extension projects. Noise from traffic is, however, still the most important source of noise nuisance in Denmark.

In May 2002, the Government set up a Road-Noise Group, which has been given the task of drawing up a broadly considered strategy to limit noise from road traffic. The Road-Noise Group consists of the following members: The Ministry of Finance, Denmark’s Road Safety and Transport Agency, the Ministry of Justice, the Spatial Planning Department, the Environmental Protection Agency, the National Board of Health, the Ministry of Transport, the Danish Road Directorate and the Ministry of

Economic and Business Affairs. The Environmental Protection Agency has chaired the Noise-Protection Group and been responsible for the secretariat function. The Road-Noise Group's terms of reference are reproduced in Annex 1.

In the Strategy, the possibility of reaching the target in the former Government's traffic management plan, *Trafik 2005*, from 1993 to limit noise from road traffic is to be emphasised. Another objective is for the Road-Noise Strategy to contribute towards ensuring a good foundation for the implementation of the EU Directive on the Assessment and Management of Environmental Noise. The Strategy is not to consist of tangible proposals for solutions for individual roads or streets. There will only be an overall assessment of the potential of various tools.

The Strategy will contain

1. a summary account of the health impacts from noise from road traffic and an assessment of the socio-economic consequences of this,
2. an assessment of tools for reducing noise from road traffic, including an assessment of the interaction between tools, the noise-reducing effects of the tools and typical unit costs associated with the tools,
3. an assessment of whether there is a need to give those actors that can realise the objectives of reducing the present noise from road traffic a change in powers and whether there is a need to develop new tools,
4. provide proposals for the financing of the expenditure associated with achieving the Strategy's goals.

The Road-Noise Strategy can be used as a starting point for deciding how any efforts against noise from road traffic can be organised in the future.

The Strategy is based on the main principles in the Government's new approach in the environmental area, *Green Market Economy – more environment for the money*, that "environmental goals should be achieved as cost-effectively as possibly" and that "there is a need for well-documented analyses of the socio-economic advantages and disadvantages of targets and means."

The Strategy provides citizens and authorities responsible with an overview that can be used to organise cost-effective local efforts against noise, balanced against local requirements for noise abatement. At the same time, the Strategy provides fresh knowledge about the socio-economic advantages of investing in noise abatement and it underlines the division of responsibility for such investments being implemented.

The Road-Noise Group hereby provides its proposals in this report.

The Road-Noise Group has carried out a number of interim studies and investigations as a background to preparing the Road-Noise Strategy. These are the following:

Interim report on *Technical Aspects in Connection with Noise from Road Traffic*

Interim report on *Noise, Health and Nuisance*
Interim report on *Economic Calculations*

2.2 Mapping of road noise

It is estimated on the basis of new mapping (*Status memo for national mapping of noise from road traffic*, the Danish Environmental Protection Agency) that today there are about 150,000 residences exposed to extreme noise nuisance, i.e. residences with over 65 dB at the façade and that there are a total of 705,000 residences exposed to road noise that exceeds the Environmental Protection Board's recommended limit value of 55 dB at the facade. These figures should be seen in light of the total number of dwellings of about 2.5 million for the whole country.

Table 2.1. Dwellings exposed to noise from road traffic 2001 **dB category**	**Number of dwellings exposed to noise**
55-60 dB	340,000
60-65 dB	215,000
65-70 dB	125,000
>70 dB	25,000
Total above 55 dB	**705,000**
Total above 65 dB	**150,000**

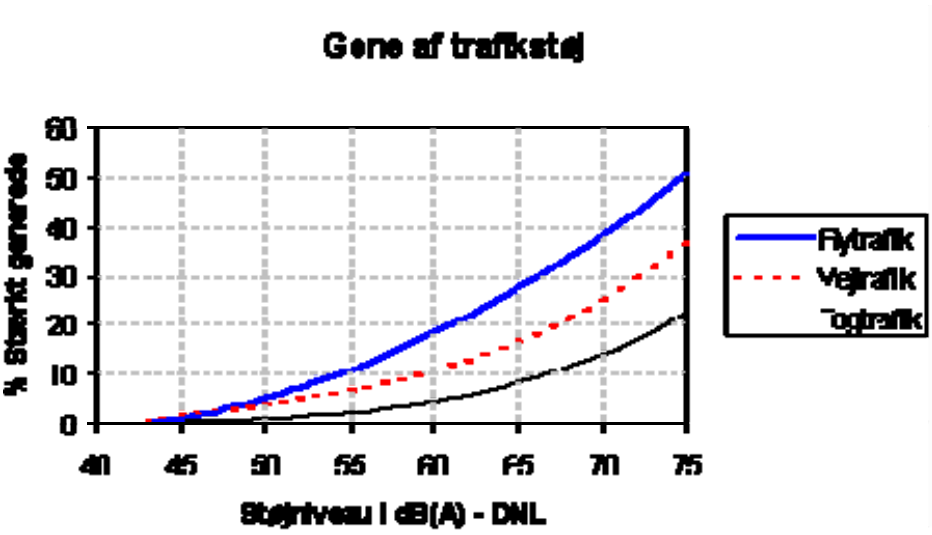
The number of dwellings exposed to noise of more than 55 dB is somewhat greater than previous mapping has shown (the old mapping showed about 500,000). This is particularly due to the new mapping including data from a greater percentage of the road network and, to some extent, because, in the new mapping of noise, contributions to noise to individual dwellings from several roads have been included. This is in accordance with it being emphasised in previous mapping that the method used could be expected to underestimate the number of dwellings exposed to noise, primarily in the 50-60 dB interval.

The new and more close-meshed mapping used in the Road-Noise Strategy as a basis for the calculation of scenarios does not provide the opportunity to calculate the individual contribution from state, county and municipal roads to the total noise nuisance. This is first and foremost because some of the dwellings exposed to noise nuisance are exposed to road noise from several types of road. Noise does not respect state, county and municipal road demarcation. The calculations available concerning the state's percentage of the noise problem (drawn up by the Road Directorate) was not calculated using a method that takes into account that noise exposure sometimes comes from several different types of road.

In order to give an impression of the order of the distribution between state roads and other roads, the Road-Noise Group has carried out a general estimated assessment of the state's percentage of noise exposure. According to this assessment, it is estimated that state roads account for 5-10 per cent of the total noise exposure. There is no corresponding mapping for county roads but the Environmental Protection Agency has carried out a rough estimate on the basis of previous mapping and assesses that the county contribution is in the range or 5-10 per cent of the total noise exposure. It is therefore estimated that 85% of the dwellings affected by noise are exposed to road noise from municipal roads.

2.3 Present limit values

The Environmental Protection Agency has issued recommended noise limits for most types of external noise. The recommended noise limits have been generally established on the basis of the perception of noise of large social groups. This is illustrated during interviews, where a large percentage of people exposed to a certain level of noise experience the noise as a considerable nuisance. As the different types of noise are not equally annoying, they must be investigated individually. In so doing, we find interrelationships as shown below in the curves for traffic noise. [1)]



(Legend to graph: Top – Nuisance caused by traffic noise
Left – % very annoyed
Bottom – Noise level in dB(A) – DNL
Right – Air traffic
Road traffic
Rail traffic)

The recommended noise limits are an expression of the noise exposure that the Environmental Protection Agency considers environmentally acceptable. It is a matter of the balance between the effects noise has on people and socio-economic considerations. The recommended limit values typically correspond to a noise level where about 10 per cent of the people tested

(those most sensitive to noise) state that they are extremely disturbed by the noise.

The regulation of noise from road traffic is different for dwellings being newly constructed and existing dwellings.

The Environmental Protection Agency has set recommended limit values for noise from road traffic in connection with planning and projecting of new residential areas along busy roads. The limit values are stated in the Environmental Protection Agency's Guidelines no. 3/1984, *Traffic Noise in Residential Areas*, and have been laid down under Section 14 of the Environmental Protection Act. This is followed up in the rules in the building regulations that new constructions and major rebuilding along roads that lead to a noise level of more than 55 dB for individual buildings are to be insulated against the extraneous noise so that the noise level indoors in the dwelling rooms does not exceed 30 dB.

No limit values have been established in respect of the existing housing stock.

No recommended limit values have been established either for the construction of new roads. However, as regards the planning of new major road systems, it has been stated in Guidelines no. 3/1984 from the Environmental Protection Agency that consideration should be taken to the consequence of noise on existing areas that are sensitive to noise. If areas that are exposed to noise are laid out for use that could lead to sensitivity to noise, provision should, according to the Danish Planning Act, be made in the district plan for the establishment of screening measures etc.

The Road Directorate has also issued road regulations that recommend that the road boards endeavour to achieve the lowest possible noise levels along new roads, i.e. 55 dB in the case of all-year residences and 50 dB for holiday homes.

The following situations can therefore be differentiated:

Table 2.2. Recommended limit values for road noise for dwellings	**Road infrastructure**	
Residential areas	Existing roads	New roads
Existing dwellings	-	(+)
New residential areas	+	+

\+ indicates that the recommended limit values are to be followed
\- indicates that the recommended limit values are not to be followed
(+) indicates that the recommended limit values are not to be followed but that there is a certain practice that applies where the limit values are included in planning.

In the case of new residential areas and to a certain extent the construction of new road infrastructure, there are regulations or practices applying that ensure as far as possible that dwellings are not exposed to nose from traffic of more than the Environmental Protection Agency's recommended limit values. In this way it is ensured as far as possible that new dwellings exposed to noise do not arise. Increases in traffic could however mean that dwellings that fall below the limit values in the planning situation are eventually above the limit values after a few years. It is therefore important to anticipate any increases in traffic during the planning situation. The rules and regulations applying do not, however, solve the problem of the many existing dwellings affected by noise, including dwellings where exposure to noise has increased as a result of an increase in traffic.

2.4 Action so far towards reducing noise from traffic

The division of responsibilities between the state, counties and municipalities

It is estimated that 90-95 per cent of residences exposed to noise nuisance are on county and municipal roads (of this about 85 per cent are on municipal roads). Therefore, counties and municipalities are primarily responsible for setting priorities for any initiatives concerning most of the road-noise nuisance.

The division of tasks between the counties and state is fundamentally based on decisions – and, as a rule, also the responsibility for financing – being taken by the authorities that are considered best suited to solving a particular task. So, some tasks are best suited to being solved locally and regionally and others to being solved from state quarters. The incentive is that the authorities that are 'closest' to a certain problem will also have the knowledge to make the best choices and prioritise in accordance with the resources they have available.

At the same time, an absolutely fundamental principle behind the latest reform of municipalities is that the authority for making decisions – including the authority for planning – and responsibility for financing were to go together. The division of tasks in the roads area has been agreed with the municipal organisations and forms the basis of the division in the Roads Act of public roads into main roads managed by the state, country roads managed by the counties and municipal roads managed by the municipalities.

As previously mentioned, the state has to a lesser extent provided grants for noise-reducing measures in counties and municipalities. These grants are not pursuant to the fundamental division of tasks but are granted on the basis of special considerations, in some cases to also test new tools or new combinations of tools. In the case of state cofinancing, one has to be aware of the risk of influencing the local decision-making process in an unintended direction.

Action to date under the direction of the state

The most important direct efforts towards reducing noise along existing roads over the last 10 years have taken place under the direction of the state and, through systematic efforts, a basis has been created for a significant reduction in traffic noise. Efforts have focused on the following main areas:

- noise reduction along existing roads
- noise reduction in connection with new constructions/widening of roads
- research, development and communication.

Noise reduction along existing roads

In the period from 1992 to 2002, the Danish Road Directorate has continually planned and carried out noise-reducing initiatives along the existing state road network with the objective of reducing health nuisances and improving the quality of life of the people who live alongside those stretches of road with the greatest noise nuisance. By the end of 2001, about DKK 212 billion had been spent on this objective as between DKK 5 and 30 million has been allocated to noise abatement in annual Budgets. In these efforts, particular focus has been put on the erection of noise screens, which have been assessed as the most suitable tool in by far the majority of those stretches of road where noise abatement measures have been taken.

It can be difficult to calculate the exact effect of these measures over a period of time as it is the nature of noise conditions that they constantly change because of new constructions, extensions to the road network and changes in traffic patterns. It is, however, assessed that as a result of these efforts, noise has been continually reduced for about 5,000 dwellings, split into about 2,000 that previously had a noise level of more than 65 dB and about 3,000 that previously had a noise level in the 55-65 dB interval. In the prioritisation of efforts, emphasis has been placed on objective criteria so that the investments that provide the greatest environmental effect per Danish Crown are implemented first. In this manner, it is ensured both that measures are typically taken where the problem is greatest and that the best possible social return on the investment is achieved.

The percentage of dwellings exposed to noise that are located alongside the state road network constitute, as previously mentioned, only a limited percentage of the dwellings exposed to noise from road traffic in Denmark. The background to the exposure to noise constituting a relatively limited problem along the state road network is that the state only manages about 2% of the total road network and that the state principally manages the general road network that connects parts of the country and creates connections between Denmark and abroad. Naturally, a large part of this road network is located outside of urban areas. At the same time, exposure to noise should be seen in the light of there being a far greater percentage of the total traffic on the state network in relation to its size.

As well at the significant efforts along the state roads, grants have also, to a lesser extent, been awarded for noise-reducing measures in counties and municipalities. An example of this that can be mentioned is the cofinancing of a large noise abatement project in Århus Municipality at Randersvej. Residents in the area were involved in connection with the planning and implementation of the project and the residents participated in the cofinancing along with Århus Municipality and the Road Directorate.

Grants have also been provided for other noise abatement projects in municipalities. The objective of a number of the projects has been – in addition to ensuring a reduction in noise – to test new tools or new combinations of tools with a view to developing new and more effective methods of reducing noise from traffic.

Noise reduction in connection with new constructions/widening of roads

During the environmental impact assessments carried out in connection with the planning of new constructions and the widening of roads, mapping is carried out with regard to the environmental impact the road system will have on the surroundings. Mapping is also carried out concerning the exposure to noise from the different alternatives and the question of noise exposure and options for restricting this are therefore already involved in the introductory planning in connection with the construction of new roads.

When implementing large projects, these are initially based on the Environmental Protection Agency's recommended limit values for noise when establishing new housing beside existing traffic installations (55dB for roads, 60 dB for rail) also applying as the objective for new traffic installations that pass through existing continuous urban areas.

Noise-reducing measures are thereby an integral part of planning in connection with new constructions and extension projects on the state road network when the stretch of road passes through continuous urban areas where exposure to noise in particular constitutes an environmental problem. In connection with larger extension projects, noise-reducing measures will be designed to include both abatement of noise from the extension work itself and existing noise. Opportunities for restricting noise during extension projects where the alignment of the construction and the adjacent housing are fixed, may however be more limited than during new constructions where the alignment of the construction can be included as a planning parameter. These opportunities will therefore depend on the actual extension project and the extent and nature of the existing noise problems.

An example of a large extension project such as this is the Motorring 3 motorway around Copenhagen. The remarks to the proposed construction Act (L214, adopted 27 May 2003) state that about DKK 190 million of the total construction budget of about DKK 1,800 million is expected to be spent on noise abatement, or approximately 10 per cent. Completion of this project will mean a significant reduction in the existing noise nuisance so that only a limited number of dwellings will be exposed to more than 60 dB

from the motorway after the extension. These dwellings will be offered subsidies for facade insulation.

Traffic investments in progress and investments approved, together with the proposed state investment plan for new traffic investment, cover a total of 20 road projects of varying sizes, and realisation of these will contribute to reducing noise nuisance along the state road network. It is estimated that the projects in the investment plan will lead to a reduction of about 1 per cent in the total residences in Denmark exposed to noise nuisance. The effect on the noise impact along the state road network is estimated at between 15 and 20 per cent.

Research, development and communication

Over the last few years, a number of extension projects have been carried out with the objective of developing new methods in connection with the restricting of noise from road traffic. For instance, in the 1990s, two Danish experiments were carried out in which noise-reducing road surfaces were examined. At Viskinge on Zealand, five test surfaces were tried out on a country road with a view to assessing the different surfaces' potential for reducing noise. There have also been trials carried out at Østerbrogade in Copenhagen using fine-grained drain asphalt. A trial project was begun in 1999 with a view to gathering experiences of double-course drain asphalt and this is still ongoing. In the trial project, experimental sections of road were put down at Øster Søgade in Copenhagen and measurements are being taken here on an ongoing basis.

The purpose of these trials is both to test the noise-reducing effects of various surfaces and to test durability, costs, winter qualities etc. It has been attempted to communicate the results of the various trials in different contexts with a view to ensuring that the results come to the attention of a wide circle of people.

In connection with the erection of noise screens, emphasis will also be put on the ongoing development of the screens with a view to developing effective, durable screens that require limited maintenance costs. Work is also ongoing on developing screens that can be adapted to the countryside in a considerate manner. A number of initiatives have also been implemented in this area with a view to the wide communication of experiences in the development of noise screens.

Action in municipalities and counties to date

Municipalities and counties have also taken action to reduce road noise. The Road-Noise Group has not had access to summary material that can highlight this action in greater detail. In the following, emphasis will be placed on examples of these efforts These examples were reported on at a road noise seminar that the Ministry of Transport and Environmental Protection Agency held with selected counties and municipalities in April

2003. Other examples can be found in municipal and county planning documents.

It is estimated that it is primarily in the larger towns, where exposure to noise is greatest, that goal-oriented work has been carried out on mapping and reducing noise. Noise problems in municipalities have typically been put on the agenda in connection with local traffic management schemes and environmental action plans. Throughout the 1990s, about 2/3 of large urban municipalities have drawn up local traffic management schemes and environmental action plans where road noise is mapped.

Thus, the City of Copenhagen has been working for many years on reducing road noise and further efforts are planned in connection with the next traffic management scheme and environmental action plan that are in the process of being drawn up. Over the last few years, the local authority has, for instance, spent a considerable amount on facade insulation during urban renewal projects and has also had grant schemes for noise insulation.

An example of tangible action is Århus Municipality, which has set up a municipal noise insulation fund of DKK 4 million, which requires 50 per cent cofinancing from the residents. Over the last 10 years, Copenhagen County has erected noise screens on county roads and has plans to continue these efforts.

Private efforts to date

Private citizens have to some extent undertaken noise insulation, sometimes with grants from public funds. The extent of these efforts has not been mapped. These investments and the differences in property prices reflect the fact that road noise is typically viewed as a nuisance by individual citizens, but, of course, differently from person to person.

If one wishes, as a private citizen, to reduce noise nuisance in one's own dwelling there are, as the technical preliminary studies for this strategy show, often some technical opportunities for undertaking investments that can reduce noise and even provide the homeowner with an increase in the value of their property. An increase that, in many cases, can be expected to more than compensate for the costs of the investment.

The fact that more citizens do not invest in facade insulation may depend on a number of factors. It could be that they are not aware of the damage to health resulting from road noise or the technical opportunities for and advantages of noise abatement. If this is the case, this strategy could act as a contribution towards increasing the local knowledge base. It could also be a case of organisational/legal barriers to carrying out noise-reducing measures. For example, the right of disposal is often limited if one lives in an apartment, particularly if renting, of course. Finally, some residents of dwellings exposed to noise have had to resign themselves to the noise problem because they have a low income and thereby a lack of funds to invest in noise-reducing measures or because they are only expecting to live

there temporarily until they can find something better and do not, therefore, want to invest in such improvements.

Action to date with regard to trains and planes

The number of dwellings exposed to noise from train traffic of 70 dB and above (in the case of noise from trains, the definition of severe noise nuisance is from 70 dB) has been estimated at 17,000 dwellings. Since 1986, the National Rail Administration has erected noise screens along those stretches most exposed to noise, which has reduced the number of dwellings exposed to noise of more than 65 dB by 4,300 dwellings. In addition, the National Rail Administration has, by the end of 2001, offered 6,400 dwellings grants for noise insulation and 2,300 homeowners have accepted the offer. The funds have been granted through the National Rail Administration's noise funds for abating noise from trains. Less noisy trains have also had an effect.

In order to reduce the number of dwellings exposed to noise from aircraft, the environmental authorities have environmentally approved airports and aerodromes for more than 20 years. In this way, limits have been established for the operation of airports and aerodromes, including the periods during which planes may take off and land, and how many operations may be carried out.

The environmental authorities have also laid down requirements for, for example, the erection of noise protection. In connection with the establishment of new aerodromes or significant extensions to existing aerodromes or airports, noise impact areas have been set up in the regional development plans. Overall, this has led to it being possible to reduce the number of dwellings exposed to noise from aerodromes and airports.

2.5 EU regulations

Three directives have been adopted in the EU that are of importance for efforts directed at road noise.
An EU directive from 1996 concerns limit values for the emission of noise from vehicles. The effect of this directive has not yet had its full impact as many vehicles registered prior to 1996 are still being driven on Danish roads. It can therefore be expected that there will be a noise-reducing effect over a period of time.

In 2001, a EU directive was adopted regarding noise from tyres, which was implemented in Denmark in 2002. [2] According to the directive, all newly registered vehicles are to have noise-approved tyres fitted from February 2005. From 1 October 2011 at the latest, most tyres are to be noise-approved, which means that the full impact in terms of noise will not be realised until 3-4 years later when all tyres are replaced.

The new EU Directive on the Assessment and Management of Environmental Noise (the Noise Directive) which was adopted in 2002

[3]means that all EU countries are to appoint responsible authorities for carrying out noise mapping in 2007 and drawing up noise action plans in 2008. The background is that external noise, including traffic noise in particular, is a widespread problem in the entire EU – according to the European Environment Agency, more than 50 million EU citizens are exposed to noise levels from road traffic of more than 65 dB. It is therefore desired to give a higher priority to noise abatement efforts in an interaction between the EU and the Member States.

For Denmark, the directive means, among other things, that noise maps and action plans are to be drawn up in 2007/08 for Greater Copenhagen and roads with traffic of more than 6 million vehicles a year. In 2012/13, noise maps and action plans are also to be drawn up for Odense, Århus and Aalborg and for roads with more than 3 million vehicles a year. This procedure will subsequently continue every five years. The directive does not contain requirements for specific limit values or measures and it is up to the Member States to decide these themselves.

According to the directive, mapping and action plans are to be published and communicated and sent to the Commission.

In the directive, a number of minimum requirements for the action plans are listed: For instance, these include:

- Estimates of the number of people exposed to traffic noise, identification of problem areas and possible initiatives
- A summary of measures already established or planned to reduce noise
- Initiatives planned within the next five years for the reduction of exposure to noise
- Long-term strategies
- Assessment of costs.

It is mentioned in the directive that the purpose of the directive is also to create a basis for Community measures being developed to reduce noise originating from major sources. With a view to this, the Commission is to submit suitable legislative proposals to the European Parliament and Council by no later than July 2006. It must therefore be expected that the Commission will make proposals for further measures that can be implemented to reduce noise from road traffic at source, e.g. as regards noise emissions and tyre noise from vehicles as such initiatives are particularly favourable to regulate at Community level.

The directive orders all Member States to carry out noise mapping in accordance with common guidelines both with regard to new noise indicators L_{den} (day, evening, night) and L_{night}, and by using common measurement and calculation methods for determining exposure to noise. L_{den} is to be used to assess nuisance and is a 24-hour weighted average value, where evening and night values count proportionally higher. L_{night} is an 8-

hour average value for the night period and is to be used to assess disturbance to sleep.

Danish noise mapping has, to date, only calculated noise exposure as $L_{Aeq, 24h}$ i.e. as 24-hour equivalent values but, in connection with the implementation of the directive, the common European indicators are to be used. The EU directive also sets requirements for mapping down to L_{den} 55 dB(A) and L_{night} 50 dB(A) as a night value.

The Road-Noise Strategy can be seen as the first step in the process towards complying with the EU Noise Directive as regards assessing possible initiatives and their consequences.

The process that is now being initiated with the Road-Noise Strategy and EU directive should therefore be seen taking a long-term view. We are dealing with problems that concern many of the country's citizens but to different extents. For some people, this could lead to real health problems while, for others, road traffic may be an everyday nuisance. Some of the health problems develop over a number of years, just as it takes time to organise and implement initiatives to reduce noise. There is therefore a need for a long-term strategy.

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3 Health effects and nuisance

3.1 The effects of noise on health

People experience traffic noise differently, but the majority of people experience it as annoying and it can lead to stress-related physical and mental reactions.

The World Health Organisation (WHO) has defined good health as a state of physical, mental and social well-being and not just a condition where one is free of sickness and ailments.

According to WHO, noise from traffic can lead to annoyance and have health effects such as communication difficulties, headaches, high blood pressure, greater risk of heart disease, hormonal effects, stress and sleeping difficulties Noise can affect performance and children's learning ability and motivation. Thus, noise has adverse health effects on people.

Sleeping difficulties include both physiological effects such as changes to sleeping patterns and more subjective effects such as problems falling asleep, the feeling that quality of sleep has deteriorated and side-effects such as headaches and tiredness. Laboratory tests show that noise changes sleeping patterns and affects sleep in the direction of waking up more frequently and a smaller percentage of deep sleep.

Children and noise is an area that has not been investigated very much. The fundamental development of language and learning takes place during childhood and even being subjected to low noise constitutes a risk for the cognitive development of a child being impaired or delayed. Noise can have a negative effect on a child's learning, motivation and concentration and can provoke stress reactions and impair a child's sleep, which is important for the regeneration of the body and brain. [4]

On the basis of the assessment of health effects, WHO recommends a number of limit values. WHO recommends a limit value for noise of 55 dB at the façade of a dwelling and 30-45 dB for the indoors environment, depending on the requirements for disturbance of the various phases of sleep. For educational situations, WHO recommends that the noise level does not exceed 35 dB.

Traffic noise leads to health effects and can, over a longer period of time, lead to real health problems. In the following, a distinction is therefore made between annoyance such as the nuisance experienced from traffic noise, and health effects, by which is meant the impact on health and which requires treatment. It should however be pointed out that annoyance can also have consequences for health.

3.2 The assessment of annoyance

In Denmark and abroad, many studies have been carried out into the relationship between exposure to noise and its effects on people. The results have been set out in so-called dose-response curves. The studies have typically been carried out as field surveys, where it is investigated whether people feel very annoyed, a little annoyed or not annoyed by noise at the various noise levels.

There is a great difference in the degree of annoyance individuals experience at different noise levels. Some people state that they do not feel any annoyance even at noise levels of 70 dB. Others are very annoyed by noise levels of 35-40 dB. The annoyance from noise experienced by individuals varies due to a number of internal and external factors and it is not possible to predict the annoyance from noise than an individual will experience. It is, on the other hand, possible to establish the relationship between exposure to noise and noise nuisance for social groups.

Fear can be of great importance to the noise nuisance experienced. [5] People who fear the source of noise (e.g. planes), experience greater noise nuisance than people who do not have the same fear. In addition to the exposure to noise of dwellings, noise in the surrounding neighbourhood can also be of significance regarding the noise nuisance experienced. [6] Dwellings with high levels of noise will often have increased levels of air pollution and traffic in the vicinity, i.e. people also experience a reduced quality of life due to reduced air quality and an increased risk of accidents. This affects the degree of noise nuisance experienced.

In a Danish survey of health and ill health in 2000, a representative section of Danish adults was asked about noise nuisance from traffic within a 14-day period. [7].
Nationwide, a total of 6.2% stated that they had been irritated, 4.1% that they had been a little irritated and 2.1% that they had been very irritated. Generally, more young people were irritated by traffic noise than older people. The same number of men as women stated they had been irritated by traffic noise. In some areas of Denmark, proportionally more people said they had been irritated than the national average – in the City of Copenhagen and Fredriksberg Municipality 13.2 % stated they had been irritated, in Copenhagen County 7.0% and in Roskilde County 8.0%. At the other end of the spectrum, only 3.1% in Viborg County stated they had been irritated by traffic noise.

The survey also showed that 43.9% of people in multi-storey housing and 55.6% of people in buildings holding 2-4 families live alongside roads with through traffic. There were proportionally more inhabitants of this type of dwelling who were irritated by traffic noise (11.5% and 9.9% respectively) while only 1.9% of inhabitants of country properties were irritated. Among those who live beside a road without through traffic, 3.1% were irritated. The noise nuisance from traffic experienced does not vary depending on socio-economic or educational backgrounds.

Traffic is one of many sources of noise that lead to nuisance in dwellings. According to the survey, noise from neighbours was a nuisance to 7.7%, installations in the dwelling irritated 2.8% and companies in the vicinity of the dwelling irritated 1.5%. A total of 15.7% had been irritated by one or more form of noise over a 14-day period. Questions were also asked about how people experienced the risks from noise. In this respect, 8.8% replied that they were a little or very concerned about their own health due to noise in or around their home.

3.3 Socio-economic analysis of the effects of noise

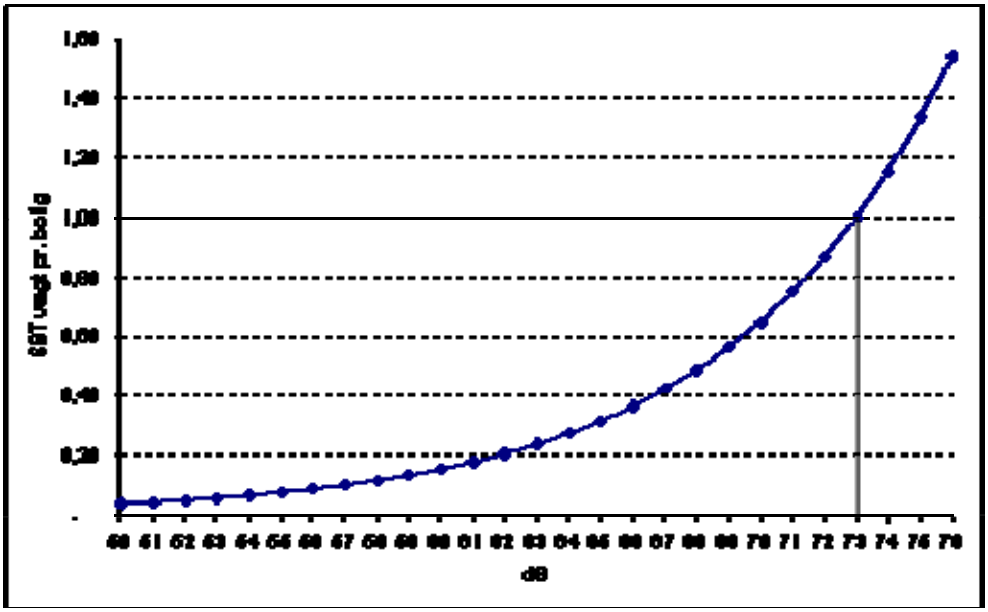
In *Noise Considerations for New Constructions* from 1989 (the Road Directorate), the dose-response curve, based on Danish surveys, that forms the basis for the establishment of an irritation curve expressing the so-called Noise Exposure Figure for given dB levels is shown. This relationship is used in connection with the Road Directorate's Traffic Cost Benefits unit prices and present estimate of unit prices for noise, cf. below.

In order to be able to express a unit cost for noise, a connection between the noise nuisance experienced and the level of noise is used, which is estimated against the background of the field survey reported in *Noise Considerations for New Constructions* from 1989. On the basis of how many people have replied that they feel extremely irritated by road noise, it is calculated what percentage of interviewees felt extremely irritated at each level of noise. These percentages have formed the basis for the estimation of an irritation curve.

The irritation curve increases exponentially. This means that an increase in noise of 1 dB in, for example, the 70-75 dB interval is experienced as more irritating than an increase in noise of 1 dB in the 55-60 dB interval. A weighted value of noise exposure at different levels of noise is measured by the so-called noise exposure figure, where dwellings with high levels of noise are weighted higher than dwellings with lower noise levels. A noise exposure figure of 1 is equivalent to a dwelling exposed to noise with a noise level of 73 dB at the façade. The exposure to noise for the dwellings exposed to noise nuisance (700,000) is, when converted, equivalent to about 159,000 noise exposure figure units.

These calculations of the noise exposure figure are used in practice when, for instance, selecting stretches of road for the erection of noise screens to achieve a cost-effective measure. In addition to this, the noise exposure figure is used in the calculation of noise costs in the Road Directorate's Traffic Cost Benefit unit prices that are used in socio-economic assessments in the transport sector, for example, assessments of road projects and are also used in this project. The connection is illustrated in the figure below:

Figure 3.2. The irritation factor curve for exposure to noise



Source: The Road Directorate

In connection with socio-economic assessments of a noise abatement initiative, it is useful to be able to put a value on, i.e. calculate in money, the reduction achieved. A unit price is used for this, calculated in DKK per noise exposure figure. As regards noise nuisance experienced, also called noise costs, these are to reflect how much people exposed to noise nuisance are willing to pay for a reduction in the level of noise.

Different methods are used to put a value on noise nuisance, of which the house price method is the most widespread. The present unit price for noise, which is part of the Traffic Cost Benefit unit prices, is based on an older

analysis of house prices. The Environmental Protection Agency has just completed a new house price study, the results of which are used in the socio-economic assessments in connection with the Road-Noise Strategy. [8]

A house price study is based on the proximity to, for example, a busy road forming part of the price of a house in line with things such as living space and the age and condition of the house. By setting up a model in which the individual characteristics are included, the effect of an individual parameter, in this case road noise, can be isolated and a value established for this parameter.

This description of the housing market is based on a number of assumptions, including that there should be many buyers and sellers, full information on the options and prices, the house price market should be able to be described as one market and it is to be a case of a real market (free pricing). This last assumption is the reason why the rental market cannot be used as the starting point for a house price study in Denmark as rental is widely regulated. It is, on the other hand, assessed that these assumptions are reasonably satisfied for the Danish housing market that the study is based on.

The fact that the house price analysis is based on owner-occupied dwellings does not mean that it is assumed that it is only house owners that are willing to pay in order to reduce noise levels. The house price analysis uses this method to deduce how willing people generally are to pay in order to reduce noise levels. It could be discussed whether a house price study based on detached houses is a relevant expression of willingness to pay in order to reduce noise levels in apartments. All things being equal, it must be assumed that there is less of a willingness to pay in the case of apartments than for detached houses.

An alternative to a house price study is to ask people directly about their willingness to pay to reduce noise levels. In this respect, it may however be difficult to ensure that people give honest answers. The advantage of using the house price method is that the results are based on market data and thereby reveal real differences in the willingness to pay in the case of dwellings that are very exposed to noise and dwellings that are less exposed to noise. Ideally, the results of the house price survey should be supplemented with the results of a questionnaire where people are asked directly about their willingness to pay to reduce noise levels. No combined study such as this had, however, been carried out when the Road-Noise Group’s calculations were carried out.

There are probably also other environmental effects that correlate with the noise effect, for example the barrier effect, aesthetic effects, air pollution and insecurity about living next to a busy road. The house-price study has attempted to investigate this, but it was not possible to quantify these relationships. It is likely, however, that there is some correlation with the other nuisances from living beside a busy road. [9]

In the Environmental Protection Agency's study, it is estimated that the prices of houses exposed to road noise above 55 decibels (dB) situated beside 'ordinary' roads fall by 1.18% per dB while the corresponding figure for houses situated beside motorways is 1.64% per dB. The average value is estimated at 1.2% per dB. This corresponds to an average fall in house prices of about DKK 13,000/dB. It should be emphasised that people do not typically suffer financial losses as a result of road noise as they have obtained a reduction in the price of the house due to the noise. However, increases in traffic on nearby roads after the purchase of a house can lead to a fall in the value of the house.

Even though the house price study does not provide a complete picture due to the aforementioned uncertainties, it has been chosen as the best possible estimate of the costs associated with noise nuisance from roads in the Road-Noise Strategy. It can be attempted to estimate the annual socio-economic costs against the background of the house price study and the mapping of dwellings exposed to noise. In view of the fact that only houses and not apartments are included in the study and in view of the other uncertainties stated, the figures put forward must, on the basis of present knowledge be referred to as an upper estimate of the effects of noise nuisance.

On the basis of mapping, the total noise exposure figure for dwellings exposed to noise above 55 dB is calculated as the sum of noise exposure figures for all dwellings. [10]

The result of the Environmental Protection Agency's house price study (price reduction of 1.2% per dB) can be converted to an average annual fall in the house price per dB and then, by means of the irritation curve for noise, this is converted to a value per noise exposure figure. Once converted, a price of about DKK 33,100/noise exposure figure per year is obtained, which can be interpreted as the value of a reduction in exposure to noise of 1 noise exposure figure.

The annual socio-economic costs of the effects of the nuisance can subsequently be calculated as the 159,000 noise exposure figures multiplied by the cost per noise exposure figure of DKK 33,100, which comes to DKK 5.3 billion.

The result of the house-price study by the Environmental Protection Agency applies to single-family residences, but in the socio-economic analysis it has been applied for all types of dwelling. It is likely that a lower unit price applies for flats, where there is no outdoor garden or similar, but there is no data available regarding this at the present time to calculate this For this reason, there can be a tendency towards the average unit price of all types of dwelling being overvalued in the socio-economic analysis.

3.4 Calculation of health effects

The documentation on actual health effects from being subjected to road noise is generally weak and without conclusive evidence (i.e. without clear

proof). There is however agreement that there is *some* evidence of a relationship between exposure to road noise and the occurrence of heart disease although the extent of the increased risk has a relatively large degree of uncertainty attached to it.

New surveys particularly point to being subjected to noise during the hours of the night and the disturbance to night sleep ensuing from this being the most significant factors for high blood pressure and/or heart disease (see, for example, Maschke 2002). Future studies and research in the area will be able to quantify in greater detail the significance of noise at night for health effects.

In connection with the preparation of the Road-Noise Strategy, a study has been carried out, which provides the first estimate of the extent of the impact on health. The study was restricted to including heart disease and high blood pressure on the basis of the expectation that the costs associated with these would be heaviest. In the case of heart disease, so-called ischemic heart disease has been looked at, i.e. an insufficient supply of blood to the heart, for example, in connection with the hardening of the coronary arteries (only described as heart disease in the following).

The best available basis for an assessment of the health effects of road noise appears to be a summary analysis of scientific studies (van Kempen et al. 2002) which reports an excess health risk of 9% per 5 dB of an increase in exposure to road noise during daylight hours (06.00 – 22.00) for noise in the area of 51-70 dB for heart disease. The study points out the occurrence of a dose-response relationship between exposure to noise and heart disease in respect of a wide spectrum of noise levels and therefore contradicts the use of analyses carried out solely on values for risk for the highest levels of exposure. As regards the relationship between road traffic noise and high blood pressure, it was decided to use the same risk factors for high blood pressure as reported for heart disease in this study.

Developing these conditions depends on a number of factors, of which road noise is a minor element. However, the analysis does indicate that exposure to noise from road traffic can lead to an increased risk of the aforementioned diseases.

On this basis, conservative estimates indicate that around 800-2,200 people in Denmark are admitted to hospital each year with high blood pressure or heart disease due to the extra risk from traffic noise. Even more uncertain estimates indicate that 200-500 people die prematurely each year following these diseases. Therefore, road noise seems to be the cause of an increase in poor health and consequent mortality from the categories of disease mentioned above. Future research will be able to qualify and further quantify this assumption.

In addition to this, there are further effects that have not been assessed in this context, such as impact on a child’s ability to learn, stress, sleeping problems and a reduction in productivity etc. The estimate of the economic

costs of health effects caused by traffic noise therefore only contains costs in respect of the diseases selected - increased blood pressure and ischemic heart disease.

3.5 Economic analysis of health effects

Previously there have been no assessments available, in a Danish context, of health costs associated with health effects as a result of noise from road traffic in Denmark. Health costs have therefore, until now, been only very roughly estimated as 50% of the costs associated with noise nuisance in the official unit price for noise (cf. the Road Directorate's Traffic Cost Benefit Unit Prices).

On the basis of the study into the impact on health, the Road-Noise Group has had an initial assessment of the extent of the costs associated with heart disease and high blood pressure as a result of noise from road traffic in Denmark carried out.

The health costs in the health sector, i.e. medicines, doctors visits and treatment at hospitals has, on the basis of the information available, been conservatively estimated as in the region of DKK 40 – 100 million annually and, with an even greater degree of uncertainty, when including death and sickness absences, as in the range of DKK 300-900 million with the estimate of lives lost based on costs and in the range of DKK 1,800 – 5,100 million with the estimated loss of life based on the willingness to pay. The corresponding central estimates of total costs have been calculated at about DKK 0.6 billion (based on costs) and about DKK 3.4 billion (based on the willingness to pay) respectively annually.

It should be noted that the estimate of the economic costs of damage to health only includes the costs of the diseases selected – high blood pressure and heart disease. In addition, road noise is, as previously mentioned, believed to be the cause of other damage to health such as hormonal effects, stress and sleeping problems, which it has not been possible to quantify in the Road-Noise Group's work. Conversely, high blood pressure and ischemic heart disease are assessed as being associated with the greatest social costs.

3.6 Calculation of a new unit price for road noise

The willingness to pay for a reduction in noise, the barrier effect, insecurity etc. that can be inferred from the house price study (the Environmental Protection Agency 2003) has been used as an expression of the willingness to pay for the noise nuisance that individual people experience. There are, in addition, other costs for the community such as the costs of treatment in the health service as a result of sickness absences caused by noise from road traffic. As, in the majority of cases, costs such as these are not met by the individuals, they cannot be expected to be reflected in the house prices.

In addition there is the question of whether, when buying a house, people are aware of the long-term effects on health as a result of road noise let alone including them in their decision to buy. There are no studies available that can confirm or deny that long-term effects on health are involved in the decision to buy. It is therefore assumed that the social costs consist of two elements: 1) nuisance and 2) health costs.

On the basis of the Environmental Protection Agency's house price study, the social costs as a result of nuisance can, as previously described, be estimated at DKK 5.3 billion per year. In most cases, home owners are compensated for the noise nuisance through lower purchase prices and therefore do not suffer a financial loss.

The information available for assessing the costs of the impact on health is relatively flimsy, but it can, however, be assessed that the application of the estimates prepared in the Road-Noise Strategy give a better estimate than methods used to date, where the costs were estimated, as previously mentioned, as 50% of the costs associated with noise nuisance.

The total annual costs for the community as a result of road noise have therefore been estimated as the sum of DKK 5.3 billion related to nuisance, and DKK 0.6 billion (cost-based) or DKK 3.4 billion (based on willingness to pay) related to health effects – a total of between about DKK 5.9 and 8.7 billion per year.

In order to be able to use the information on the costs of damage to health in the socio-economic analyses, it is necessary to convert the costs to a unit price per noise exposure figure in the same way as for nuisance. The socio-economic unit price for damage to health as a result of road noise has been estimated at DKK 3,900 per year/noise exposure figure and DKK 21,250 per year/noise exposure figure for the cost –based estimate and the estimate based on the willingness to pay respectively. The total unit price for noise is subsequently calculated as the sum of the unit prices for nuisance and damage to health, as shown in the table below.

Table 3.1. The socio-economic unit price for road noise **Type of cost**	**DKK per year/noise exposure figure**
The effects of noise nuisance Health effects	33,100 3,900/21,250
Total	**37,000/54,350**

Note: As regards health effects, the two values state the costs estimated for the cost-based valuation and willingness-to-pay-based valuation of death respectively.

As shown in the table, the socio-economic unit price has been calculated at about DKK 37,000 and DKK 54,000/noise exposure figure per year,

depending on whether the cost-determined or willingness-to-pay estimate for the health costs are used.

In this context, it has been decided to use the willingness-to-pay estimate, which is consistent in relation to the recommendations in both the Ministry of Finance's and Environmental Protection Agency's recommendations concerning socio-economic impact assessments. This means that the unit price used for noise reduction in the calculations in this project comes to DKK 54,350/ noise exposure figure.

The unit price can be interpreted as the total value of a reduction in noise exposure of 1 noise exposure figure. Cost effectiveness is also measured in DKK per year/noise exposure figure, whereby an expression of the costs per total noise reduction achieved is obtained. By comparing the return and the costs an expression of the net social return on noise-reducing initiatives is obtained.

The Road Directorate's unit price is DKK 53,090 per year/noise exposure figure. The total unit cost used in this project is therefore largely unchanged in relation to the Road Directorate's official unit price.

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4 Technical tools and assumptions

4.1 Summary of technical tools

There are a number of technical tools available for reducing noise from road traffic. Initiatives that reduce the noise at source, i.e. noise-reducing surfaces and quieter tyres and vehicles reduce the noise in street areas in general but noise screens and facade insulation, for example, reduce the noise more specifically for any given dwelling. In return, these tools have a pronounced effect on the dwelling in question.

In the Road-Noise Strategy, a distinction is made between technical tools and political management control measures. By technical tools is meant the technical measures that can reduce exposure to noise in the physical reality. This applies, for example to the use of quieter road surfaces. On the other hand, by political management control measures are meant the political initiatives intended to ensure that a tangible development takes place, for example, the use of noise-reducing road surfaces when replacing asphalt on stretches exposed to noise nuisance. Political management control measures are described in greater detail in Chapters 7 and 8.

The Road-Noise Group has decided to focus its analyses on the following technical tools, which are considered relevant in relation to the reduction of noise from road traffic:

1. Reduction at source:

- A tightening up of the requirements for noise emissions from vehicles
- Promoting the use of quieter tyres
- Quieter road surfaces (double-course drain asphalt or thin-layer surfaces)
- Reduced speeds
- A ban on lorries

2. Reducing the distribution:

- Moving to bigger roads
- Erection of noise screens

3. Reduction at the recipient:

- Facade insulation
- A change in the use of buildings

In addition, there are a number of other tools, such as a reduction in the extent of traffic, moving road traffic to other quieter forms of transport, covering roads (tunnels), regulating the distribution of traffic throughout a 24 hour period, etc.

In the case of quieter road surfaces, the two types of road surface analysed illustrate the spectrum as regards effects and costs of quieter road surfaces. As regards the practical implementation of noise-reducing initiatives, it is, however, import to be aware that a third option, single-course drain asphalt, is also a relevant alternative, cf. below.

The technical potential

When estimating the technical potential of tools, a distinction can be made between, on the one hand, general tools (requirements for noise emissions from vehicles and promoting the use of quieter tyres) and tools specific to stretches of road (other tools analysed):

In the analysis of tools, the noise-reducing effect and the associated economic costs and returns are analysed using different strengths. By strength is meant the spread of the tools, i.e. for the geographical tools, the geographical spread and for the general tools, the degree of implementation.

General tools. For these tools, the technical potential is expressed in terms of full penetration, i.e. corresponding to the tool in question being introduced in all vehicles. In the case of this type of tool, the strength will depend on how rapidly the tool is brought into use.

The reduction in noise realised depends on the degree of implementation. The higher the percentage of vehicles where quieter tyres, for example, are fitted the greater the reduction in noise.

Tools specific to stretches of road. For these tools, the technical potential is expressed per unit (for example, the dB reduction through using thin-layer surfaces). The full utilisation of the technical potential will in this case correspond to the tool such as, for example, thin layer surfaces being used on all stretches of road. In the case of this type of tool, the strength and thereby the total reduction in noise will depend on how many kilometres of road are affected.

In the case of this type of tool, the noise reduction realised will depend on how and to what extent the tool is implemented. The more dwellings exposed to noise nuisance there are in the areas selected, the greater the effect the tool will have.

In the case of tools specific to stretches of road, the number of model kilometres that the tool will be applied to is calculated. The calculation of model kilometres is, like the basic mapping, based on a number of model towns that are scaled up to a national level.

It should be emphasised that the forms chosen are only examples and that other forms may be considered that reflect greater or smaller degrees of use. The forms have however been chosen in order to reflect a broad spectrum of options.

Calculation of effects

The analyses were carried out using the model for noise distribution, TP-Noise. Using this model, exposure to noise is calculated in principle for each individual dwelling in a number of model towns taking into consideration the effect of the tools used. It has not been possible to include dwellings in rural districts in the model and these are therefore managed outside the model.

The stretches of road where the effect of the tools is greatest are selected on the basis of calculations in the noise distribution model, TP-Noise. A method has been prepared that sorts all stretches by noise contributions to dwellings and this is used to identify the stretches that contribute the most noise per km. It should be emphasised that the stretches have been selected analytically, which means that a number of other aspects that should be taken into account in connection with the tangible planning of noise measures on actual stretches of road have not been included in the selection.

The effects of the individual tools can be measured as the change to the distribution of the number of dwellings in the individual 1 dB categories. A new distribution of the number of dwellings has therefore been calculated for each tool form.

The price of a new technology will often gradually fall as the technology becomes more widespread. It has been attempted to assess this effect in the estimate of costs for the various tools. The analyses of the technical tools have been based on the background knowledge, conditions and assumptions below.

4.2 Tightening up of the requirements for noise emissions from vehicles

The contact of the tyres with the roadway and the motor are the primary sources of noise emissions from vehicles. There are however also contributions from exhaust emissions, induction, resonance from the chassis and wind noise. In the case of technical tools, a distinction is made between vehicle noise and tyre noise.

The requirement for the maximum noise from new vehicles has been regulated in the EU directive, which was tightened up most recently in 1996. This means that a new private car may emit a maximum of 74 dB during an acceleration test at 50 km/h, while buses and lorries may emit maximums of 78 and 80 dB respectively. The effect of the full penetration of this regulation has been included in the reference scenario.

According to the new noise directive, EU Directive 2002/49/EC on the Assessment and Management of Environmental Noise, the Commission is to submit proposals for reducing noise at source by no later than 2006. It must be expected that this will also include proposals for reducing road traffic noise, which is by far the most dominant noise nuisance in the EU. The possible tightening by the EU of the requirements for vehicle noise will probably only have a limited effect by 2010. For 2020, the technical potential for a reduction of 1 dB in the noise emissions from vehicles is assumed.

It is very difficult to assess the costs that will be associated with realising this potential, especially as car manufacturers rarely develop technology solely with the purpose of reducing vehicle noise. In a recent Norwegian report "Mulige tiltak for å redusere støy [Possible initiatives for reducing noise]" (SFT, 2000) an estimate from a car manufacturer of DKK 1,000 per dB reduction per vehicle for light vehicles and DKK 4,000 for heavy vehicles is used. Despite much uncertainty about these estimates of costs, this is seen as the best basis available and is therefore used in the Strategy.

4.3 Promoting the use of quieter tyres

Noise from tyres is associated with the number of tyres, tyre width, the elasticity of the rubber, depth of the pattern and segments and the composition and suspension of the tyre. Good noise qualities may be in conflict with good wearing resistance because good wearing resistance is achieved by using hard rubber, which creates more noise than soft rubber. Good noise qualities are not, on the other hand, assessed as being in conflict with good friction qualities and thereby safety aspects, according to new

studies. The investigations also show that quieter tyres are normally favourable energy-wise.

The requirements for tyre noise are regulated in a EU directive (2001/43/EC). The effect of the penetration of this regulation has been included in reference developments. After the calculation of the reference development, new German measurements were published in the summer of 2003 [11], which point in the direction of a greater reduction in the noise levels of tyres than previously assumed as a result of the EU regulations and efforts of tyre manufacturers. The measurements actually indicate that the average noise level from the tyres of private cars is significantly lower than assumed in the calculations in the Road-Noise Strategy. In the case of the individual categories of tyres, the improvement is 1.5 – 2 dB. As these results became available at a very late stage in relation to the completion of this report, they have not been used in the calculations.

The technical potential over and above the effect of the EU regulation is assessed at about 1.3 dB on roads with high speed limits (outside towns) and 0.7 dB on roads with low speed limits (in towns) in 2020 in the scenario calculations. The potential has been assessed on the basis of measurements of tyres in the period from 1993 – 1998. The new German measurements indicate a tendency for the difference in noise between the different types of tyres to have become less, which provides less potential for the reduction of tyre noise. A calculation of the technical potential using the new German noise figures demonstrates a technical potential of up to 0.9 dB on roads with high speed limits and up to 0.4 dB on roads with low speed limits. Technological developments could possibly reduce the potential further in the future. These results became available at a very late state and were therefore not used either in the scenario calculations.

The most significant cost associated with the phasing out of noisy tyres is seen to be the possible price difference between quieter tyres and other tyres. The actual pricing on the tyre market, including the importance of tyre noise, is difficult to predict, which makes the price difference difficult to assess. In a Norwegian study, an estimate of 10% as the additional price for quieter tyres was used and this has been taken as the basis of the calculations in the Road-Noise Strategy. This estimate must, however, be regarded as very uncertain. Based on prices of average tyres, the additional price per tyre is, on this basis, estimated at about DKK 65 for tyres for private cars and DKK 210 for tyres for commercial vehicles and lorries.

COWI has obtained access to data on the 2001 prices for the tyres in the aforementioned recent German study. [12]. On the basis of the Norwegian and German information, it appears reasonable to assume that there is no price difference for quieter tyres compared with more noisy tyres. Due to the late appearance of the new German price data, the scenario calculations are however based on an assumption of an additional price of 10%.

In the analysis of tools, the calculation has been carried out based on full realisation of the technical potential. In the modelling, it is assumed that the

effect of the management control measures that will be brought into use in 2020 will, on average, have reduced the emission of noise from all vehicles so that the full technical potential is realised. The cost effectiveness would be affected by alternative modelling, where a smaller percentage of the technical potential is realised as a lower incidence of quieter vehicles would reduce the effect proportionally more. A noise reduction of only 50% in the vehicles in the motor vehicle population would therefore result in only 33% of the technical potential being realised, while 75% would result in 50% of the technical potential being realised.

The Environmental Protection Agency has, in addition, as an arithmetic example and supplement to the scenario calculations, carried out a calculation of the effect of a tax on quieter tyres, whereby there would be only a 33% realisation of the technical potential. The calculation is based on the results of the recent German survey. I.e. that an overall technical potential is assumed here that is only half as great as the assumed scenario calculations and it is assumed that quieter tyres are generally more expensive than the more noisy tyres. [13]

4.4 Noise-reducing road surfaces

Previously, motor noise was the dominant source of traffic noise – particularly in urban areas where speeds are comparatively low. But as motors have become less and less noisy, it is now noise from the contact of tyres with the road surface that has become the dominant source, even at lower speeds. Danish and international experiences have indicated over the last few years that there is a potential for combating road traffic noise by using noise-reducing road surfaces.

Drain asphalt has high noise reducing qualities due to the noise absorption in the cavities of the surface. Drain asphalt has a draining effect, which prevents problems with water splashing on roads during rain, which increases the safety and comfort of road users. Noise reduction can be increased by using double-course drain asphalt, whereby the noise-absorbing qualities are improved due to the greater thickness. The first time double-course drain asphalt was laid was in Holland in 1990 and, in 1999, experimental sections of road were tested at Øster Søgade in Copenhagen. The use of drain asphalt is more expensive in construction and operation and requires special consideration during winter maintenance.

An alternative to drain asphalt is a thin durable type of surface, if greater durability and lower prices are compared to the possible noise-reducing effect. These new types of thin-layer surfaces do not require any special winter maintenance but are probably less noise-reducing than drain asphalt. Work is going on in parallel in an EU project, SILVIA, on testing these new types of thin-layer surfaces, which have less of a noise-reducing effect but are, on the other hand, less expensive than drain asphalt. As this work has just commenced, there is not as yet any Danish documentation on the effects in terms of noise of these new types of thin-layer surfaces.

Experience also shows that it is only when replacing an old surface with a less noisy surface that there is the potential for reducing noise. Research over the last few years has shown that it is possible to divide surfaces into three different classes. noisy, normal and noise-reducing surfaces. This insight has been incorporated into the Nordic model for calculating road traffic noise, in which it is possible, using a table, to correct the noise level in relation to the actual surface.

The Road-Noise Group has decided to carry out calculations for two types of noise-reducing surface, double-course drain asphalt and a less noise-reducing, but less expensive surface, which could, for example, be a new type of thin-layer surface. Single-course drain asphalt is assessed as being somewhere between these two surfaces in terms of effect and cost.

Double-course drain asphalt

On the basis of results documented in the report, "Development of noise-reducing road surfaces for urban streets" from the Danish Transport Research Institute, 2002, the following effects are assumed in the case of double-course drain asphalt.

Table 4.1. Assumed noise-reduction from double-course drain asphalt **Road surface**	**In urban areas**	**Outside urban areas**	
	50 km/h	70 km/h	110 km/h
Double-course drain asphalt	3 dB	4 dB	5 dB

Source: The Danish Transport Research Institute, 2002 and *Noise-reducing road surfaces*, a memo of 6 May 2003 from the Environmental Protection Agency.

In the calculation of additional expenditure, it is assumed that the asphalt is replaced at the time when it would nevertheless be renovated due to wear and tear. The calculation of the additional expenditure on double-course drain asphalt is based on information from the Danish Transport Research Institute, 2002 and information from the Road Directorate. The costs of construction and lifetimes of the two types of surface are shown in the table below.

Table 4.2. Investment costs, double-course drain asphalt **Road surface**	**Price (DKK/m²)**	**Lifetime (years)**
Asphalt concrete (normal asphalt)	42.00	15
Double-course drain asphalt:		
Bottom course drain asphalt	72.45	15

Top course drain asphalt	40.25	7.5
Grooved asphalt concrete	35.00	15

Source: The Danish Transport Research Institute, 2002 and *Noise-reducing road surfaces*, a memo of 6 May 2003 from the Environmental Protection Agency.

In addition to this, there are increased running and maintenance costs for cleaning and winter maintenance etc. of surfaces.

Lifetimes are estimated at 15 years for dense asphalt concrete and 7-8 years for the top layer of drain asphalt and 15 years for the bottom layer of asphalt. The total additional expenditure calculated for 1 km of double-course drain asphalt instead of asphalt concrete in respect of the different road types is shown in the table below.

Table 4.3. Additional cost of double-course drain asphalt **Road type**	**Estimated additional annual cost (DKK/km)**
Urban street	165,000
Ring road	200,000
Motorway	260,000

Source: COWI calculations
Note: An internal discount rate of 6% has been used in the calculation of the total costs over the 30-year period and the subsequent conversion to an annual rate. 2001 – price level

Analyses have been carried out for the following strengths:

1): *Widespread use* of double-course drain asphalt, equivalent to about 2357 km of urban streets, 1272 km of ring roads/country roads and 325 km of motorway.

2): *Moderate use* of double-course drain asphalt, equivalent to about 477 km of urban streets, 384 km of ring roads/country roads and 4 km of motorway.

3): *Limited use* of double-course drain asphalt, equivalent to about 209 km of urban streets, 102 km of ring roads/country roads and 1.5 km of motorway.

Other types of surface

Another option is specially developed noise-reducing thin-layer surfaces, which have less of a noise-reducing effect, but are on the other hand less expensive than drain asphalt. On the basis of Dutch experiences, it is

assessed that thin-layer surfaces would reduce noise by 1.5 dB in urban areas and 2 dB outside urban areas, compared with dense asphalt concrete.

The assumptions used for thin-layer surfaces are shown in the figure below.

Table 4.4. Effect (expressed as a reduction in noise) of an open thin-layer surface **Road surface**	**In urban areas**	**Outside urban area**	
	50 km/h	70 km/h	110 km/h
Open thin-layer surface	1.5 dB	2 dB	2 dB

Source: *Noise-reducing road surfaces*, memo of 6 May 2003 from the Environmental Protection Agency.

In the additional expenditure on open thin-layer surfaces, it is assumed above that the asphalt is replaced at the time when it would nevertheless be renovated due to wear and tear. The calculation of additional expenditure is based on information from the Road Directorate. Construction costs and lifetimes are shown in the table below.

Table 4.5. Investment costs, thin-layer surface **Road surface**	**Price (DKK/m²)**	**Lifetime (years)**
Asphalt concrete (normal asphalt)	42.00	15
Open thin-layer surface	48.30	15

Source: Working note from the Road Directorate.
Note: 2001 – price level

As shown in the tables, the construction costs are assessed as only about DKK 6.30 more expensive per m2 for the thin-layer surface compared with ordinary asphalt concrete. No increased running and maintenance costs are expected. At the same time, the lifetime of open thin-layer surfaces are assessed as the same as the lifetime for conventional types of asphalt. The additional expenditure calculated for 1 km of thin-layer surface instead of asphalt concrete in respect of the different road types is shown in the table below.

Table 4.6. Additional cost of thin-layer surface **Road type**	**Conversion of additional cost to an annual rate (DKK/km)**
Urban street	5.200
Ring road	9.000

Motorway	17.500

Source: COWI calculations
Note: An internal discount rate of 6% has been used in the calculation of the total costs over the 30-year period and the subsequent conversion to an annual rate.
2001 – price level

As shown in the table, the additional annual cost of laying thin-layer asphalt is between DKK 5,200 and DKK 17,500 depending on the type of road.

Thin-layer asphalt is used at the same strength as for double-course asphalt.

4.5 Speed reductions

Road traffic noise can be reduced by reducing speeds There is also a correlation between driving patterns and noise as smooth driving with little braking and acceleration emits less noise. The effect of reductions in speed of 10 km/h at various initial speeds is shown in the table below.

Table 4.7. The effect of selected examples of reductions in speed **Change in speed**	**Reduction in noise**
From 130 to 120 km/h	0.6 dB
From 120 to 110 km/h	0.7 dB
From 110 to 100 km/h	0.7 dB
From 100 to 90 km/h	0.7 dB
From 90 to 80 km/h	1.3 dB
From 80 to 70 km/h	1.7 dB
From 70 to 60 km/h	1.8 dB
From 60 to 50 km/h	2.1 dB
From 50 to 40 km/h	1.4 dB
From 40 to 30 km/h	0.0 dB

Source: The Road Directorate, 1998
Note: Assuming that 10% are heavy vehicles and that the highest speed of lorries is 90 km/h. There is therefore not such a great effect in going down from 130, 120, 110 or 100 km/h. The noise reductions stated can be added together if it wished to assess the effect of reducing speed by more than 10 km/h.

Heavy traffic does not contribute as much to noise reduction when reducing speeds of below 60 km/h as private cars. On roads with a lower percentage of heavy traffic, the noise reduction will therefore be greater if speed is reduced from 60 km/h to a lower level.

Road renovations and increased speed checks

It is assessed that reductions in speed as a tool has very few direct costs associated with it in terms of administration, control, new signs etc. when the reduction in speed is effected solely by reducing the speed limit. If, on the other hand, the reduction in speed is effected by using road structures (traffic calming) or increased speed checks, this will involve not insignificant direct costs. In the arithmetic example it is assumed that the reduction in speed is achieved by a change in road signs with the same control as before.

There will be a number of negative and positive side effects from a reduction in speed. Reduced speed could lead to a loss of time for road users but, on the positive side, it could lead to a reduction in the number of accidents, lower fuel consumption and less air pollution. These side effects are included in the calculation of the costs of the tool. The Road Directorate's Traffic Cost Benefit calculation prices are used for the loss of time and the reduction in accidents. In the case of fuel consumption and emissions, it is assumed that the effect would be marginal, compared to the other effects.

It should also be mentioned that there are other related effects of speed reductions that should be taken into consideration if the tool is used. It is the case that drivers may want to change their choice of route and look for roads where the travelling time or distance is shorter. Secondly, public transport will become relatively more attractive than car transport, which could be expected to generate a shift and, thirdly, the number of trips would become fewer and shorter for drivers as conditions would be worse for drivers. It is assessed that these effects are small and insignificant, taking a socio-economic view, and no attempt has been made to quantify them.

The analyses of tools have been carried out for a reduction in speed of 10km/h for the following strengths.

1) Widespread use of reductions in speed, equivalent to approx. 1,690 km, divided into stretches with initial speeds of primarily between 50 and 80 km/h.

2) Limited use of reductions in speed, equivalent to approx. 164 km, divided into stretches with initial speeds of primarily between 50 and 80 km/h.

4.6 Ban on lorries

Lorries and buses have a significantly higher level of noise than private cars. Heavy vehicles are therefore, on average, 8 – 11 dB noisier than private cars. The percentage of heavy vehicles may therefore be of significance with regard to noise as an increase in heavy traffic leads to an increase in noise. If it is possible to reduce the percentage of heavy vehicles on a stretch of road, the noise can be reduced.

Bans on lorry traffic in specific geographical areas or at specific times, such as at night, could therefore reduce noise significantly. On stretches with very heavy traffic, a ban could reduce noise by up to 2 dB. The actual noise reduction on actual stretches will depend on the specific circumstances, such as speeds on the stretch, the volume of traffic and the percentage of heavy traffic. In addition, the total noise power will depend on to what extent lorry traffic moves to other roads or other times.

If, for example, a ban on lorries at night means that lorries instead drive during the day, this will not have any effect on the 24-hour equivalent noise level calculated. This will, on the other hand remove the high maximum levels at night and thereby be of great significance to the inhabitants who do not have to hear the noise of the lorries while they sleep. This also applies to the loading and unloading of goods, which many feel irritated by in the early hours of the morning.

No tool analyses have been carried out in respect of this tool.

4.7 Moving to bigger roads

It is possible to reduce traffic by generally moving traffic without the volume of traffic being reduced overall. The movement of traffic from one road to another can provide a positive effect in terms of noise if the flow of traffic moved constitutes a larger percentage of total traffic on the first road than it will on the road it is moved to. This will be particularly appropriate if the flow of traffic moved constitutes such a relatively small percentage of the total traffic on the new road that the increase in noise is not audible.

The movement of traffic is a commonly used tool today. When planning new urban areas and traffic-calming in existing urban areas, one of the primary objectives of traffic planning is to create a structuring of the road network that moves traffic to roads that are particularly suitable. This restructuring of traffic may, for example, be done by building a bypass road to reduce traffic in a densely built-up main street. This will reduce noise on the main street where many people live and increase it on the bypass road where only a few people live.

Part of the effect of this tool has therefore already been realised but there is deemed to still be a potential for further noise reduction. No tool analyses have been carried out in respect of this tool, as the effect – as in the case of lorries – will be entirely dependent on the actual circumstances associated with the initiative.

4.8 Erection of noise screens

The erection of noise screens along the road can reduce the spread of road noise and thereby reduce exposure to noise. Noise screens have the most effect when erected on main roads that go through a comparatively densely built-up housing area as most people benefit from a reduction of the noise on these roads. The noise screens require space between the road and housing

and can only be used on so-called unbuilt-up highways, i.e. roads from where there are no side roads or other direct access to dwellings. This means a significant limitation with regard to the use of noise screens as a tool. The erection of noise screens and embankments is a commonly used tool and about 20 km of noise screens have been erected along the state road network.

With a 3 m high noise screen situated 10 m from the middle of the road, on flat ground 2 m above the surface of the ground, a noise reduction of 12 dB can typically be achieved up to 25 m from the road. If the distance is increased to 150 m from the road, the noise reduction achieved will typically be 5 dB. In the case of distances of 30 – 70 m from the road, an average noise reduction of 8 dB can be established for a 3m high noise screen. This average value has been used in the calculations. For 4 m noise screens an average noise reduction of 10 dB has also been used.

The stretches on which noise screens were used in the analyses were selected with consideration to whether it was possible to erect a screen on the stretches. It was primarily the main roads with few or no direct road accesses that were chosen for the erection of noise screens as screens generally have the greatest effect, measured in noise exposure figures, along these roads. Additionally, these roads largely satisfy the requirement for space between buildings and the road and there not being dwellings with direct access, which makes it physically possible to erect noise screens.

Tool analyses have been carried out for the following strengths:

1) *Widespread use of 3 m screen*, equivalent to the erection of 3 m noise screens on 712 km of road.

2) *Limited use of 3 m screen*, equivalent to the erection of 3 m noise screens on 164 km of road.

3) *Widespread use of 4 m screen*, equivalent to the erection of 4 m noise screens on 712 km of road.

4) *Limited use of 4 m screen*, equivalent to the erection of 4 m noise screens on 164 km of road.

The construction costs assumed for the noise screens are shown in the table below:

Table 4.8. Investment costs, noise screens **Type of screen**	**Price (DKK/m²)**	**Lifetime (years)**
3 m high noise screen	2,450	30
4 m high noise screen	2,250	30

Source: The Road Directorate

Annual running and maintenance costs are estimated at 0.5% of the total construction costs. The total expenditure on noise screens is calculated over a 30-year period and converted into an annual additional cost. The results for 1 km of road with noise screens on both sides are shown in the table below.

Table 4.9. The annual expense of noise screens on both sides of 1 km of road **Types of screen**	**Conversion of additional cost to an annual rate (DKK/km)**
3 m high noise screen	1,150,000
4 m high noise screen	1,400,000

Source: COWI calculations
Note: An internal discount rate of 6% has been used in the calculation of the total costs over the 30-year period and the subsequent conversion to an annual rate.

In addition there are other effects with regard to the visual environment, air pollution and the risk of accidents. These have not been quantified, but are deemed to be of little significance in relation to the other costs.

4.9 Facade insulation

Insulation of the facades of dwellings can reduce noise in the indoors environment. The solution is not ideal, as this is only effective with closed windows and the insulation does not reduce the noise in outdoors areas. The most common form of facade insulation is the use of noise-reducing windows to replace conventional windows (single-glazed or double-glazed windows). Noise-reducing windows can also have the same good energy-conserving qualities as ordinary energy-saving windows. Facade insulation is a commonly used tool today.

There is a risk of too little ventilation in sound-proof dwellings resulting in a poor indoors climate and health problems. If existing dwellings without outdoor air inlets have new effective sound-proof windows installed without, for example, suitable outdoor air inlets being installed at the same time so that ventilation continually takes place through the windows and which, in addition, will be required more frequently after the replacement of windows than is the case for an airtight window construction, we are back where we started.

There are however sound insulating outdoor air inlets and it is stated in building regulations that the measurement of sound insulation at the façade is to be with open outdoor air inlets. It is also essential that the residents are aware that their dwelling is now more sealed so it may be necessary for them to change their practices with regard to airing so as to avoid indoor climate problems and problems with dampness.

The returns in terms of noise are greatest in relation to single glazing and least in relation to the newest double-glazed windows. Typically, the sound insulation at the facade is improved by 5-15 dB and there is the possibility of reductions of up to 20 dB. In the analysis of tools, an average effect of 10 dB has been assumed.

Tool analyses have been carried out for the following strengths:

1) *Widespread use* of facade insulation equivalent to façade insulation being used on all dwellings over 65 dB.

2) *Moderate use* of facade insulation equivalent to façade insulation being used on all dwellings over 70 dB.

3) *Limited use* of facade insulation equivalent to façade insulation being used on all dwellings over 73 dB.

The estimated investment costs for façade insulation in the form of noise-reducing windows is stated in the table below:

Table 4.10. Investment costs, façade insulation **Type of dwelling**	**DKK/dwelling**
Apartment	25,000
House	50,000

Source: The Danish Transport Research Institute, 2002 and the Road Directorate

There are not deemed to be additional running and maintenance costs associated with noise-reducing windows compared with ordinary windows. Furthermore, it is not deemed that there are any significant side effects associated with façade insulation over and above the energy aspects.

4.10 Change to the use of buildings

Even where several tools are used to reduce noise both at the source and its spread, it will be difficult in some areas to reduce the noise to an acceptable level. In these cases consideration may be given to closing dwellings in the areas affected by noise. The noise problem can then be reduced by changing the use of the areas and buildings most exposed to noise.

No specific models have been drawn up for tools for changes to the use of buildings.

Interaction with other effects

In a number of cases, there may be an interaction with tools introduced for other reasons, such as out of consideration to road safety or reductions in air

pollution. For example, a reduction in speed in order to provide improved road safety may also lead to a reduction in noise. This however depends on the actual design as a reduction in speed by using sleeping policemen may lead to noise from acceleration and braking.

It is also conceivable that there could be an interaction with measures introduced to improve air quality, e.g. environmental zones, where a change in the make-up of traffic could have a positive impact in terms of noise.

There could also be an interaction in terms of noise when introducing energy-saving windows as noise-reducing windows could have the same energy-saving qualities as ordinary energy-saving windows.

It would then be possible to build in noise consideration in connection with other environmental planning so that gains could be achieved in this way in several areas with lower costs.

5 Impact assessment of tools

5.1 Socio-economic method

In this chapter, a socio-economic assessment of the costs and gains there will be for the community through introducing the individual noise-reducing tools, used to various extents, also called ‘strengths’. Calculations have been carried out for each tool for three strengths, widespread, moderate and limited.

Behind these levels there is a tangible theoretic assessment of the distribution of the tools for use in the theoretical calculations, e.g. widespread use of double-course drain asphalt in the terminology of the Road-Noise Strategy means drain asphalt being laid on 2357 km of urban streets, 1272 km of country roads and 325 km of motorway. The detailed assumptions for the various distributions of the different tools are described in greater detail in Chapter 4.

The costs of implementing the individual tools are compared with the estimated economic benefit that the community would gain through the intended reduction in exposure to noise. We are therefore dealing with model calculations and the calculations of the socio-economic impact of implementing the tools have been carried out without a decision being made on which actors could in a given case finance the investment associated with the implementation of the tool.

The tools have been analysed on the basis of both a so-called cost-effectiveness approach and a so-called cost- benefit approach. In the first

approach, the costs of the various tools are calculated and compared for achieving a given reduction in noise (measured in noise exposure figures). In the second approach, the social profit from the tool in the form in question is calculated.

The assumptions used for the analyses follow the Ministry of Finance and Minister of the Environment's recommendations for preparing socio-economic impact assessments. This means that:

- A market price based approach is used, i.e. all prices are calculated in market prices.
- A net payment factor has been included, i.e. public expenditure is converted to prices that reflect the consumption options that another use of the resources could have provided.
- Tax distortion losses have been included, set by the Ministry of Transport at 20%. I.e. the public expenditure is increased by this factor in order to reflect the distortion of the economy that the collection of taxes causes. In connection with this, some assumptions have been made regarding the public expenditure's percentage of the total expenditure (see table).

Table 5.1.: Assumptions regarding the public percentage of investments in tools **Tool**	**Investments – public percentage**
Tightening up of vehicles' noise emissions	0%
Promoting quieter tyres	0%
Noise-reducing surfaces (double course drain asphalt)	100%
Noise-reducing surfaces (thin-layer surface)	90%
Speed reductions	-
A ban on lorries	-
Moving to bigger roads	-
A change in the use of buildings	-
Erection of more noise screens	85%
Facade insulation	75%

Source: The Danish Environmental Protection Agency

- Where possible, other effects, e.g. effects such as lost time and a reduction in the risk of accidents have been included in connection with reductions in speed.
- A discount factor of 6% has been used in accordance with the recommendations of the Ministry of Finance.
- When calculating the socio-economic price of noise reduction a time horizon has been used that is sufficiently long that all essential costs and benefits of the tool are included. This means, for example, that

when calculating the price of noise screens a time horizon of the probable service life of the noise screen is used.

- In the case of individual management control measures, costs of implementation, administration and control (e.g. administration of a duty on tyres) may occur in addition to the actual costs. The costs of this are deemed to be insignificant in relation to the total costs and are not, therefore, included (see also the footnote regarding quieter tyres at the end of Chapter 5).

In the cost-benefit analysis, the effect achieved in the form of noise reduction is to be given a value. The unit price of this has, as previously described been reviewed and calculated at DKK 54,350 per noise exposure figure.

In the case of façade insulation, where an effect can be achieved indoors, the noise effect has been valued at 60% of the above value, equivalent to DKK 32,600 per noise exposure figure.

The cost effectiveness is calculated in DKK per year/noise exposure figure and the socio-economic net result is calculated in DKK per year. Running and investment costs are therefore annualised, i.e. converted to annual costs and compared with the reduction in noise exposure figure calculated for the tool and year in question.

5.2 Reference development

In order to assess the opportunities for reducing road traffic noise in the future, the reference development for the number of dwellings exposed to noise in 2010 and 2020 has been calculated where the effects of the legislation already adopted and the Road Directorate’s forecasts concerning traffic trends have been included. No other effects have been included in addition to this, e.g. changes in housing stock, changes in settlement patterns etc.

The effects of the significant investments in noise protection paid for in connection with the Government’s investment plan have not been included in the reference development. These investments will primarily ensure that new road projects do not cause new noise problems, while existing noise problems can also be reduced during extension projects along the state road network. It can be estimated that the projects in the investment plan will lead to a reduction of about 1 per cent in the total residences exposed to noise nuisance or 15-20 per cent of the dwellings affected by noise along the state road network.

The basis of the reference development is the latest available mapping of the number of dwellings exposed to noise, which shows that there are today approx. 150,000 residences in Denmark exposed to severe noise nuisance. This mapping is based on a sample of towns that have, together, been deemed to provide a representative picture for the whole of Denmark.

It is estimated that the effect of the EU's 1996 limit values for the emission of noise from vehicles will have its full impact by 2010 and will lead to a reduction in noise of 1 dB in towns and ½ dB outside. The effect of the EU's tyre directive of 2001 is also expected to have achieved full penetration by 2010 and to lead to a reduction in noise of 0.1 – 0.2 dB in towns and 0.3 dB outside towns. In light of the effect of these measures and traffic trends, the distribution of dwellings exposed to noise nuisance in 2010 and 2020 has been calculated.

The calculations show that the effects of the EU's 1996 limit values for the emission of noise from vehicles and the requirements for tyre noise in 2020 more than offset the increase in noise that increases in traffic will cause. The number of dwellings exposed to severe noise nuisance will thus fall to 135,000 dwellings exposed to severe noise nuisance in 2020 in the reference development (a reduction of 10%). The number of dwellings exposed to noise above 55 dB in the reference development is estimated at 673,000 in 2020 (a reduction of about 30,000 dwellings). The distribution of the number of dwellings exposed to noise nuisance along state roads, county authority and municipal roads is assumed to be unchanged.

The calculation is shown in the table below:

Table 5.2. Dwellings exposed to noise nuisance, reference development, 2010 and 2020 **dB**	**Number of dwellings, 2001**	**Number of dwellings, 2010**	**Number of dwellings, 2020**
< 55	1,815,911	1,872,536	1,848,585
55-59	342,086	322,104	329,742
60-64	215,916	203,928	207,929
65-69	124,859	107,504	115,978
70-74	22,266	15,248	18,939
>=75	585	334	480
Total >= 55 dB	705,712	649,118	673,068
Total >= 65 dB	147,710	123,086	135,397
Total	**2,521,654**	**2,521,654**	**2,521,654**

Source: COWI calculations
Note: The exposure to noise for dwellings in rural districts, which constitute 12% of the total percentage of dwellings, has not been corrected with regard to a growth in traffic and the impact of regulations already adopted.
It is not expected that there will be any increase in the number of dwellings. Any new dwellings would, however, be expected to fall into the category of below 55 dB, cf. the legislation applying regarding limit values for new constructions. The lack of agreement in the calculation of totals is due to rounding off in the calculations.

5.3 Results of analyses of tools

Using the previously described models, the analyses of tools shows the results below with regard to reductions in the number of dwellings exposed to noise nuisance, the reduction in the weighted noise exposure (noise exposure figure), cost-effectiveness and socio-economic net result.

Table 5.3. Summary of results of analyses of tools, 2020

Tool:	**Reduction in number of dwellings > 55 dB**	**Reduction in number of dwellings > 65 dB**	**Reduction in noise exposure figure**	**Cost – effectiveness in DKK per year/noise exposure figure**	**Socio-economic net result in DKK/year**
Tightening up of vehicles' noise emissions	56,200	33,000	23,300	22,900	732,000,000
Promoting the use of quieter tyres	46,100	27,100	19,100	37,400	323,000,000
Double-course drain asphalt					
Double-course drain asphalt widespread (1) *	145,900	78,300	53,100	18,900	1,884,000,000
Double-course drain asphalt moderate (2) *	54,700	64,200	33,900	6,300	1,629,000,000
Double-course drain asphalt limited (3) *	18,400	46,900	22,100	3,400	1,128,000,000
Thin-layer surface					
Thin-layer surface – widespread (1) *	63,400	45,000	29,200	1,400	1,547,000,000
Thin-layer surface – moderate (2) *	23,700	35,100	19,000	400	1,023,000,000
Thin-layer surface – limited (3) *	9,800	24,500	12,600	200	681,000,000

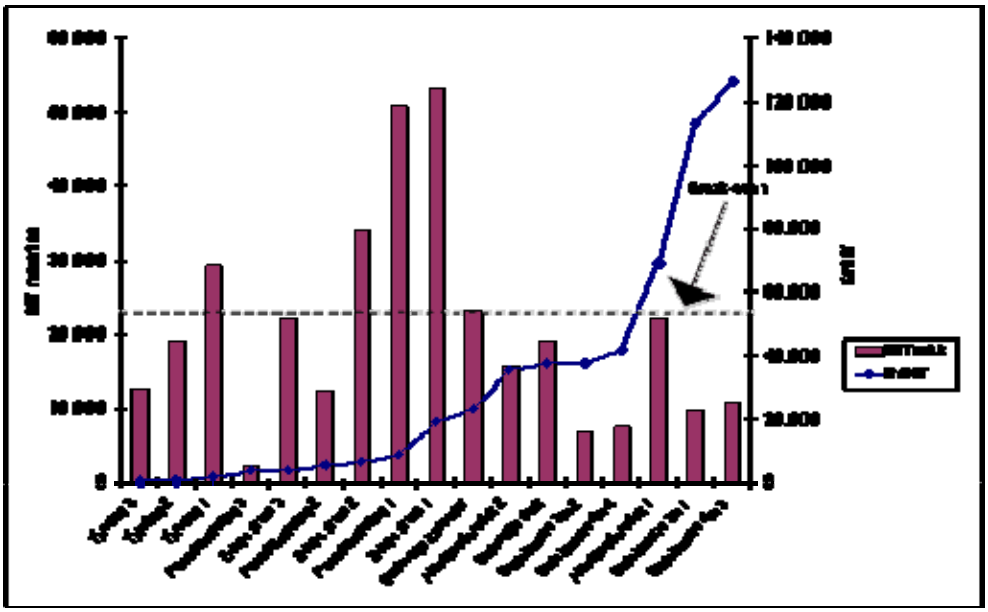
Speed reductions					
Speed reductions – widespread (1)	29,200	39,600	22,100	69,100	-326,000,000
Speed reductions – limited (2)	13,900	30,100	15,600	35,200	298,000,000
A ban on lorries	Not calculated				
Moving to bigger roads	Not calculated				
A change in the use of buildings	Not calculated				
Erection of more noise screens					
3 m noise screens – widespread (1)	25,000	14,600	9,700	113,100	-567,000,000
3 m noise screens –limited (2)	12,900	11,500	6,700	37,500	113,000,000
4 m noise screens – widespread (3)	28,900	15,400	10,600	126,500	-763,000,000
4 m noise screens –limited (4)	15,000	12,100	7,300	41,900	91,000,000
Facade insulation					
Facade insulation– widespread (1) **	0	134,900	50,900	8,500	1,228,000,000
Facade insulation – moderate (2) **	0	18,900	12,300	5,100	339,000,000
Facade insulation – limited (3) **	0	1,800	2,200	3,300	63,000,000

Notes: * It is assumed in the calculation that the stretches selected are replaced at the end of their service lives before 2010 and 2020 respectively. The cost-effectiveness is to be interpreted with this reservation.

** In the case of facade insulation, only the indoors noise level is reduced. Dwellings reduced by facade insulation stated under > 55 dB and > 65 dB will thus typically have an indoors noise level of > 30 dB and > 40 dB respectively. In the calculation of the socio-economic net result the return (reduction in noise exposure figure) from noise reduction through façade insulation is reduced by 40% to reflect this fact. *** In the case of quieter tyres, full realisation of the technical potential is assumed, cf. Chapter 4. Source: COWI calculations

The cost effectiveness of the tools is illustrated in the figure below for 2020. The figure should be interpreted with some caution, as the results are based on a number of assumptions and conditions with different degrees of robustness. Overall, however, the figures are deemed to provide a true and fair view.

Figure 5.4. The effect and cost-effectiveness of the tools, 2020



(Legend to chart: Left-hand side: noise exposure reduction (NER)
Under chart: thin-layer 3, thin-layer 2, thin-layer 1, façade insulation 3, double-course drain 3, façade insulation 2, double-course drain 2, façade insulation 1, double-course drain 1, quieter vehicles, speed reduction 2, quieter road surface, 3m noise screens 2, 4m noise screens 4, speed reduction 1, 3m noise screens 1, 4m noise screens 3)
Right-hand side: NER
DKK/NER)*Note: The broken line, equivalent to the unit price for road noise states the level of socio-economic neutrality (break-even).*

In the figure, the columns illustrate the effect (noise reduction) achieved through the forms in question of the tools, i.e. the reduction in the number of dwellings affected by noise, converted to a noise exposure figure. The noise reduction is measured in the *left-hand* axis.

The number stated for the tool describes the extent of distribution, where 1 states widespread use of the tool (e.g. the number of km where noise-reducing road surfaces are used) and a higher figure a more limited use. [14]

The tools are thus listed so that the most cost-effective tools, i.e. the tools that have the lowest costs per noise reduction achieved appear first to the left in the figure. The cost-effectiveness of each tool in the degree of distribution chosen is stated at the points on the *curve* in the figure and measured on the *right-hand* axis. By applying the tools from the left-hand side of the figure, the "greatest noise reduction for the money" is obtained while the tools on the right of the figure have the poorest cost-effectiveness.

Finally, a broken line shows the calculation value for the return of noise reduction per noise exposure figure (the unit price for road noise, cf. Chapter 3). The tool forms with a cost effectiveness below this line (i.e. all the tools with the exception of the three last ones to the right) would be socio-economically profitable based on these assumptions. The return from facade insulation does not, however, conform to the broken line, but to a line that is 40% lower as a rounded down value is used for the effect of façade insulation in the calculations (40% lower) as façade insulation only reduces noise indoors.

It should be emphasised that the cost effectiveness and the socio-economic profit are dependant on the actual form of the tool. The above are examples of such forms. Other forms could be deployed but the forms chosen provide a general impression of the spectrum of the tools' relative cost-effectiveness.

The Road-Noise Group's analysis of tools gives rise to several conclusions, of which the following can be highlighted:

- The cost effectiveness of the tools analysed depends on the form chosen. If the tool is used to a limited extent in geographical areas with a great potential for reduction it will be possible in most cases to design the tool so that it provides a socio-economic benefit.
- In the case of a large part of the tools analysed, the use of these provides a socio-economic profit in the form analysed. Only widespread use of speed reductions and noise screens of 3 and 4 metres give a socio-economic deficit on the evidence available.
- Double-course drain asphalt, thin-layer surfaces, façade insulation, noise-reducing vehicles and quieter tyres have the greatest potential noise-reducing effect. The best cost effectiveness and best socio-economic results are achieved with thin-layer surfaces, double-course drain asphalt and façade insulation.
- Thin-layer surfaces provide a somewhat lower reduction in noise than double-course drain asphalt, but as the additional costs in relation to ordinary asphalt are very low the tool is more cost-effective than double-course drain asphalt in all forms. The reduction potential of double-course drain asphalt is, however, significantly greater and double-course drain asphalt therefore provides a greater socio-economic profit than thin-layer asphalt in all forms.

- A tightening up of vehicles' noise emissions and the promotion of the use of quieter tyres provide a socio-economic profit in the forms analysed, which is connected to the fact that, despite their modest effect, they are generally effective, i.e. on the entire road network. In the calculation it is assumed that the entire technical potential is realised.
- Facade insulation only reduces the noise in the individual dwelling but is nevertheless relatively cost-effective compared with the other tools analysed. As facade insulation only reduces noise indoors, the cost effectiveness cannot be directly compared with the other tools as the return is set at a 40% lower calculation value.
- Noise screens have a good effect but relatively poor cost-effectiveness, a need of much financing and a limited distribution potential. Noise screens are a relevant tool on some stretches, but it is assessed that the potential for noise screens is less than, for example, façade insulation as a result of initiatives using screens over the last few years. In contrast to façade insulation, noise screens do have a good effect for primary outdoor gardens and similar and dwellings to the rear.

5.4 Combinations of tools

In order to illustrate the social effects and effects in terms of noise from *combining tools*, three arithmetic examples have been calculated in which costs, effects and socio-economic results of three different combinations of tools are calculated.

The tools are combined differently in the three arithmetic examples depending on whether the purpose of the arithmetic example is to achieve a great socio-economic profit, limit the need for financing or to achieve a major reduction in noise within just a few years. The three arithmetic examples are examined in greater detail in the interim report on socio-economic calculations.

Collectively, the three arithmetic examples provide a picture of the opportunities that exist theoretically on a nationwide basis to reduce the total road noise exposure on the overall road network with the emphasis on socio-economics and effect. It should be emphasised that we are only dealing with model calculations.

In practice, the tools can be combined in numerous ways and the model calculations in the Road-Noise Strategy only illustrate some of these combination options. The optimum manner of combining the tools in practice will depend on the actual circumstances and the objective it is desired to achieve.

From the analyses of the individual tools, the model calculations confirm that it will be possible to organise effective noise abatement efforts which will result in an improvement in well-being for many people and which will be socio-economically advantageous.

One of the main conclusions is also that it is important – in order to ensure a good socio-economy – that initiatives to limit the number of dwellings exposed to noise nuisance are carried out over the course of quite a few years. In so doing, the lowest costs can be achieved when, for example, the change is first made to quieter asphalt when the road surface would nevertheless have been replaced as a result of maintenance.

The model calculations show that the first noise returns are inexpensive to achieve and that it becomes increasingly more expensive to reduce road noise the greater the reduction in noise it is desired to achieve.

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6 Management control measures and financial options

In Chapter 5 on *Impact Assessments of Tools*, a picture is drawn as to which tools and combinations of these have a significant noise-reducing effect and which may be socio-economically advantageous. This chapter provides examples of management control measures that could underpin the tools and also briefly discusses the options for private financing of efforts to reduce noise.

Management control measures and competences

In the proposal for the Road-Noise Strategy in Chapter 8 it is a principal rule that relevant management control measures are indicated for each tool proposed by the Road-Noise Group. This may be a case of information initiatives, guidelines or actual legislation. Some management control measures that are particularly associated with the area of noise (e.g. limit values) or tools that could become relevant in connection with the implementation of the new EU directive on external noise are examined briefly in this section. We will also briefly touch on whether there is a need for a change to the legal authorities of counties and municipalities.

Limit values

In Denmark, recommended limit values have been introduced for some, but not all, planning situations, mainly for new dwellings, schools, institutions etc. on existing roads.

In Norway, Sweden and Switzerland, for example, limit values have been introduced for noise in several planning and noise abatement situations – in Switzerland and Norway, for example, for dwellings alongside existing roads. In Switzerland work is also being carried out on several types of limit values: planning values, critical limit values and alarm levels.

In Norway, guidelines from 1997 with limit values for local noise (and air pollution) mean that no dwelling or institution along the existing road network (and rail network) may, in 2005, have more than 42 dB indoors. This is a legal requirement that may be followed up by sanctions from the environmental authorities.

The directive on environmental noise means a new requirement for the mapping of noise at night. Common indicators for noise will be introduced which will mean that noise from road traffic noise will be worked out and calculated in a different manner than previously. In the Directive's requirement for noise action plans, efforts to control noise will particularly – but not only – address priority tasks that can be identified by relevant limit values being exceeded.

There may also be a need therefore to assess the present recommended limit values and to investigate the opportunities for using limit values as a more active and widespread management control measure in noise abatement, e.g. in connection with noise action plans.

If it is decided to introduce new limit values, it would be appropriate for this to take place as part of the revision of the Environmental Protection Agency's guidelines from 1994 on road traffic noise in residential area, cf. the next section.

Guidelines on road traffic noise

For about 20 years, noise considerations have been integrated into the planning process in connection with the construction of new housing. The background is that it is desired to ensure that the number of dwellings exposed to noise nuisance does not increase and that it is less expensive to prevent noise problems than to reduce noise once dwellings have been constructed. There is, however, a need to revise the Environmental Protection Agency's guidelines from 1984 on traffic noise in residential areas.

Today, what is required in practice of noise requirements is primarily laid down in an interaction between environmental, planning and building legislation. Guidelines where the interaction between the Environmental Protection Act, the Planning Act and the Building Act is updated and where cases of typical planning situations are described could be an overall tool that could make it easier for municipalities and counties to involve noise in day-to-day planning.

Prior to the guidelines being updated, it could be investigated how noise considerations are integrated in practice by municipalities and builders into the planning of new housing.

Noise action plans as a result of the Noise Directive

According to the Noise Directive on environmental noise Member States are, by the summer of 2008 (phase 1), to have drawn up noise action plans for major roads, major railways, major airports and agglomerations with more than 250,000 inhabitants respectively. See the following fact sheet.

FACT SHEET

The Noise Directive – The European Parliament and Council's Directive no. 2002/49/EC on the Assessment and Management of Environmental Noise.

The Noise Directive was adopted in adopted in 2002 and is to be incorporated in Danish legislation by the summer of 2004 at the latest. The most important elements of the Directive are the requirements for:

- Strategic noise mapping (Article 7)
- Action plans and the involvement of citizens when preparing them (Article 8)
- Information to the public (Article 9)

It is a consequence of the first phase of the Directive from 2007-2008 that a strategic noise map and noise action plans for agglomerations with more than 250,000 inhabitants are to be prepared. In Denmark, it is only in the Copenhagen area that there is an agglomeration of that size. The strategic noise map is to show noise from all the relevant sources of noise: Roads (state, county and municipal roads), railways, industrial plants and airports etc.

In the second phase of the Directive from 2012-2013, the same requirements will be set for Århus, Odense and Aalborg as for the Copenhagen area. In addition, roads with traffic of more than 3 million vehicles annually will also be mapped. The process of mapping and preparing action plans will then be repeated every five years.

The noise action plans are also to aim to protect "quiet areas" against noise as a minimum requirement for the action plans that are to be drawn up is that they are to contain a summary of the measures that the competent authorities intend to take for the protection of quiet areas. The noise action plans are also to particularly, but not only, prioritise in relation to how far relevant limit values are exceeded.

Over 90% of dwellings exposed to severe noise nuisance are to be found on county and municipal roads, the vast majority of which are on municipal roads. The Noise Directive will not mean that there is a duty to act against these noise problems and, neither in the Planning Act nor the Environmental Protection Act is there authority today to require counties and municipalities to reduce noise for the existing housing stock. On the other hand, there is authority in the Environmental Protection Act to intervene against noise from industry.

On the part of one county, questions have been raised about authority for the element of today's noise abatement initiatives that concerns noise abatement along existing roads. The Ministry of Transport has, however, assumed that there is authority for this in the Roads Act – an assumption that is, among other things, derived from there being express authority pursuant to Section 43(2) of the Act to undertake expropriation for the purposes of establishing noise screening.

The regulation of traffic at particular times – environmental zones

In an earlier Chapter, various tools that can be used to distribute traffic in urban areas to reduce noise exposure at times and in geographical areas where exposure is worst were described. There is authority in the Road Traffic Act to demand reductions in speed out of consideration to noise.

Authority has also been introduced in the Road Traffic Act to carry out trials with environmental zones where it would also be an option to reduce the environmental impact from traffic noise. There is also authority in the Road Traffic Act to ban the driving of heavy vehicles in certain zones and at certain times of the day. Bans like this may not, however, – in contrast to, for example, reduced speed limits – be introduced solely to address environmental considerations, including noise concerns.

It may be appropriate to draw up guidelines, for the use of counties and municipalities that wish to take increased action in the area of noise, on how specific noise requirements could be formulated, e.g. in connection with the introduction of an environmental zone. It would probably be of advantage to integrate the guidelines with work that is currently underway on environmental zones in one or more of the largest urban areas as part of efforts to reduce solid particle pollution from traffic.

Research and increased knowledge of road noise related topics

With the Road-Noise Strategy and the EU Noise Directive to hand, we can today point to a number of areas in which a greater knowledge of noise could be established.

This refers, among other things, to the development of systematic documentation concerning the noise qualities of types of asphalt. There is a great potential for quieter road surfaces so it is important to further develop and optimise this type of surface and to systematically gather operational experience.

Other research areas are knowledge of new methods of calculating noise in order to be able to implement the Noise Directive and a description of present practices in connection with new constructions in areas exposed to noise nuisance as input to revised guidelines on road traffic noise.

In order to qualify the assessment of the impact on health and costs further, it could be relevant to carry out research specifically for Danish

circumstances. In connection with research into the costs due to health problems, two alternative methods of assessing costs to the health service due to road noise have been outlined. [15] One of the methods is based on a linking of registers while the other is an empirical analysis of costs and the impact on health with observation periods of several years.

Research efforts and efforts to improve knowledge should, as far as possible, be organised in cooperation with private but particularly technical expert opinion or knowledge of noise in a development-oriented partnership.

Private financing options

Previous major noise abatement initiatives along state roads over the last few years have, as previously mentioned, been financed by the state. In addition, there have been noise-reducing initiatives financed by counties and municipalities and – to a lesser extent – by private persons (particularly in connection with façade insulation). It is envisaged that future noise abatement could be financed by private individuals to a greater extent than previously. The Environmental Protection Agency's house price survey shows that improvements in noise exposure in dwellings could be expected to lead to some increase in property values. This means the relevant homeowners will reap an economic advantage from investments leading to less noise exposure in their dwellings.

If noise-reducing measures are implemented, the relevant residents will also reap improvements in their well-being. Depending on ownership conditions, awareness of noise impacts, etc. some of this estimated improvement in well-being could lead to an increase in the market value of the properties affected. The exact size of the actual increase in market value is hard to assess, but at all events it should be a significant amount.

The increase in value could act as extra motivation for some homeowners to cofinance noise-reducing measures, particularly as the increase in value would not lead to higher taxes for the homeowner as a result of the stop on tax increases. Property value tax does not increase in Danish Crowns when the property value increases. A restriction in increases has also been introduced in respect of the taxable basic values that form the basis for the assessment of municipal land value tax so that these can basically increase by a maximum of 7% a year.

The fact that there could be an interest in private financing is supported by a questionnaire study on noise from road traffic carried out by the Danish Transport Research Institute, which shows that 15% of the respondents who replied (3,400 persons who were exposed to road noise above and below the limit value) are willing to contribute towards financing major noise reduction (Traffic noise annoyance, DTF 2003).

On the basis of income distribution policy considerations – and in accordance with the Government's quid pro quo principle it could also be said to be reasonable that those who obtain an increase in value as a result of

investments made locally in noise-reducing measures are, in many cases, involved in paying a certain percentage of the costs. This option would, however, be less relevant in those cases where an increase in exposure to road traffic noise since the date of acquisition could lead to a reduction in the market value of the dwellings for the homeowners concerned.

In order to achieve a greater reduction in noise, the principle of private cofinancing could then be considered. In the case of a given urban street it can be imagined that the road authority has decided to use a standard type of asphalt. If it is deemed advantageous to do more to reduce noise than what would have been done under normal circumstances, it could be attempted to split the financial burden in order to obtain increased funds for noise abatement. E.g. the road authority could take the initiative in contacting homeowners and providing them with information material with a presentation on the possibility of reducing noise if the homeowners are willing to enter into an agreement on a certain amount of co-financing.

As this would be a case of a voluntary scheme, the opportunities for obtaining private cofinancing would naturally vary a great deal from situation to situation. For example, facade insulation is a form of noise reduction restricted to individual dwellings and private cofinancing could therefore take place on an individual basis. In the case of quieter asphalt, which would be to the benefit of all dwellings in an area, it could be assumed that a condition for private cofinancing would be that all or the majority of dwellings that would benefit from the project provide their share of the payment.

In existing regulations there is no authority to force house owners to contribute towards cofinancing jointly adopted noise-reducing measures in areas affected by noise. One problem that would be resolved if such authority were established could be so-called free riders, i.e. house owners who do not wish to voluntarily contribute towards noise abatement but who – provided noise protection is nevertheless implemented – benefit from the reduction in noise and any increase in property values.

As regards rented dwellings, the landlord has the option of transferring his cofinancing of noise measures to the rent in the form of an increase based on the improvement. An assumption for this is that the measure leads to an increased utility value for the landlord, which is exactly the intention of the noise measure.

In rented and cooperative dwellings, the percentage of rent increases corresponding to improvements to the rented premises could trigger additional public expenditure on individual housing benefits. As a rule of thumb, the expenditure on housing benefits in rented dwellings and cooperative housing is on average about 20 Danish Øre for each one Crown increase in rent. The private burden will thus automatically be relieved. This situation must be taken into consideration in cases of private cofinancing.

In cases where an increase in exposure to road traffic noise has made matters worse for the homeowner, the house owner may also previously have obtained a reduction in land and property value and thereby in land tax and property value tax on the basis of extra exposure to noise compared with similar sites in quiet areas. This reduction may become void if there is a significant reduction in exposure to noise due, for example, to noise screens. This does not, however, mean, due to the ceiling on property value tax, that the owner will pay more property value tax.

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7 Proposed Road-Noise Strategy

7.1 Basis for the Road-Noise Strategy

Noise from traffic is the most important source of noise nuisance in Denmark. Many people live in areas where noise from traffic is a nuisance and in some cases can lead to psychological and physical problems. About 700,000 dwellings are exposed to noise from traffic of more than the recommended limit value of 55 dB for the construction of new buildings, and of these about 150,000 are severely affected by road noise (more than 65 dB).

According to WHO, noise from traffic can lead to nuisance and have health effects such as communication difficulties, headaches, sleeping difficulties, stress, high blood pressure, greater risk of heart disease, and hormonal effects. Noise can affect performance and children's learning ability and motivation. Noise thus has adverse health effects on people and long-term exposure can lead to actual health problems.

The most important initiatives to combat noise problems in existing dwellings over the past ten years have been along the state road network. From 1992 to 2002, the Road Directorate carried out noise-abatement initiatives along the existing state road network, in particular the establishment of noise screens, costing a total of about DKK 200 million. Due in part to these initiatives, and due to limits on noise from cars in EU regulations, urban traffic planning, etc. the number of dwellings exposed to noise nuisance in Denmark has not increased over the past ten years, despite the dramatic increase in traffic.

In June 2002, the Danish government set up a Road-Noise Group of relevant ministries and agencies with a mandate to prepare a *proposal for a strategy to limit noise from road traffic*, for use by the Government as a basis for deciding how to establish the best framework for future initiatives against road noise. The Danish Environmental Protection Agency (EPA) has chaired the Group and was responsible for the secretariat function.

In parallel with the Road-Noise Strategy, the Ministry of the Environment is preparing proposals for the changes to legislation necessary to implement the new EU Noise Directive. The Road-Noise Strategy could provide a good foundation for Danish implementation of the Directive. The Directive subjects Member States to an obligation to map noise from road traffic, railways, airports, and industry for the most exposed areas by no later than 2007. Moreover, by no later than 2008, action plans must be prepared to reduce noise and these plans must be made public.

It is estimated that 90-95 per cent of residences exposed to noise nuisance are on county and municipal roads (of this about 85 per cent are on municipal roads). Therefore, counties and municipalities are responsible for setting priorities for any initiatives concerning most of the road-noise nuisance.

State initiatives regarding road noise centre on the significant new investments already approved and implemented to establish better capacity and road safety in the overall road network. An example is the extension to the Motorring 3 motorway around Copenhagen. The remarks to the proposed construction Act (L214, adopted 27 May 2003) state that about DKK 190 million of the total construction budget of about DKK 1,800 million is expected to be spent on noise abatement, or approximately 10 per cent. Completion of this project will mean a significant reduction in the existing noise nuisance so that only a limited number of dwellings will be exposed to more than 60 dB from the motorway after the extension. These dwellings will be offered subsidies for noise insulation.

In connection with the Road-Noise Strategy, a preliminary survey of the extent of the health impacts in Denmark has been prepared on the basis of a study of international literature. In general, the documentation of actual health effects is weak and there is no clear evidence, however there is agreement that there is some support for the relationship between road noise and incidences of high blood pressure and heart disease. Development of these conditions depends on a number of factors, of which road noise is a minor element. However, the analysis does indicate that exposure to noise from road traffic can lead to an increased risk of these conditions.

On this basis, conservative estimates indicate that around 800-2,200 people in Denmark are admitted to hospital each year with high blood pressure or heart disease due to the extra risk from traffic noise. Even more uncertain estimates indicate that 200-500 people die prematurely each year following these diseases. Therefore, road noise seems to be the cause of a certain increase in poor health and consequent mortality from the diseases mentioned above. Future research will be able to qualify and further quantify this assumption.

The social costs of the health effects are correspondingly uncertain, but they are estimated at DKK 0.6 billion annually on the basis of a cost-based approach, and DKK 3.4 billion annually on the basis of a willingness-to-pay approach.

Furthermore, a study of the influence of road noise on house prices, carried out in spring 2003 by the Danish EPA, shows that there is a relationship between house prices and noise levels. The study shows a drop in house prices of 1 per cent for each dB road noise increases for houses by busy roads. It is uncertain how much of this drop can be attributed solely to noise impacts. In most cases, home owners are compensated for the noise nuisance through lower purchase prices and therefore do not suffer a loss.

There are probably other environmental effects that correlate with the noise effect, for example the barrier effect, aesthetic effects, air pollution, or safety aspects from living next to a busy road. The house-price study attempted to investigate this, but it was not possible to quantify the relationships. It is likely, however, that there is some correlation with the other nuisances from living beside a busy road.

The result of the house-price study by the Danish EPA applies to single-family residences, but in the economic analysis it has been applied for all types of dwelling. It is likely that a lower unit price applies for flats, where there is no outdoor garden or similar, but there was no data regarding this when the Road-Noise Group made its calculations. For this reason, and others, there can be a tendency that the average unit price of all types of dwelling is overvalued in the economic analysis.

However, the results of the house-price study have been applied in the analyses by the Road-Noise Group as an expression of the social costs of nuisance from traffic noise. On this basis, and with some uncertainty, the total annual costs of the nuisance from road noise are estimated at DKK 5.3 billion.

The house-price study provides an interesting perspective of the Road-Noise Strategy in that significant improvements in noise nuisance for dwellings will lead to increases in the prices of these properties. On the basis of this assumption, the relevant home owners will reap an economic advantage from investments leading to less noise impacts on their dwellings.

If noise-abatement measures are implemented, the relevant residents will also reap improvements in their well-being. Depending on ownership conditions, awareness of noise impacts, etc. some of this calculated improvement in well-being can lead to an increase in the market value of the properties affected. The exact size of the actual increase in market value is hard to assess, but at all events it should be a significant amount.

7.2 The Road-Noise Group's proposed Road-Noise Strategy

The Road-Noise Strategy is based on the fact that the state is responsible for noise-related efforts on state roads, and initiatives regarding the county and municipal roads are the responsibility of the relevant county or municipality.

The Road-Noise Group has made a rough estimate of the number of residences exposed to noise nuisance on state, county, and municipal roads.

It is estimated that about 85 per cent of the residences exposed to noise nuisance are along municipal roads, while state and county roads each account for 5-10 per cent. The Copenhagen area alone accounts for more than 50 per cent of the residences exposed to noise nuisance.

However, a number of the possible state initiatives will also affect the noise impact from the entire road network (e.g. promoting quieter tyres), just as the state is responsible for developing the legislative framework and guidelines for noise-related initiatives by all road authorities.

The analyses by the Road-Noise Group of the possible tools have taken as their point of departure that noise-abatement initiatives should in future be based on the most cost-effective tools in order to achieve the most environment for the money.

Calculations by the Road-Noise Group of the possibilities and consequences of achieving the goal of the previous government in Trafik 2005 to come down to 50,000 residences exposed to severe noise nuisance by 2010 show that the only way to achieve this goal is through extremely large investment (about DKK 7 billion), and not in a cost-effective manner. With this background, the Road-Noise Group proposes that efforts against road noise are planned over a longer time horizon so that they can be organised more cost-effectively. The Road-Noise Group considers it appropriate that noise-abatement initiatives are assessed in conjunction with the preparation of noise action plans in 2007-2008 by the authorities responsible, see the Directive.

The Road-Noise Group's proposed state initiatives to reduce impacts from road noise are presented below. Implementation of these proposals, as well as the EU Directive on external noise, could form the framework for the overall efforts in Denmark to reduce road noise.

Proposed state initiatives in the Road-Noise Strategy

1. Danish efforts within the EU cooperation to tighten the requirements regarding exposure to noise from vehicles and tyres should be enhanced.

2. Consumers should be informed of the possibility of changing to quieter tyres.

3. The current level of protection in connection with approved and planned traffic investment in the state road network should be retained, and this will contribute towards a significant reduction in noise levels along state roads.

4. The possibility of changing to windows with noise-absorbing and energy-saving properties should be included in future activities for energy-efficient windows to be conducted in cooperation with the glazing sector.

5. As documentation for noise-reducing road surfaces becomes available, information activities on the effect of different types of noise-reducing road surfaces should be enhanced with a view to creating a better decision-base for road authorities to use this tool.

6. In connection with the ongoing replacement of asphalt surfacing on state roads, in light of the documentation at hand and the given construction and operating budgets, there should be assessments of whether there are grounds for using noise-reducing road surfaces.

7. The guidelines on road noise in residential areas should be updated to account for both the Road-Noise Strategy and the EU Directive on noise.

8. Municipalities and counties should be encouraged to be aware that the Danish Road Traffic Act contains provisions that the police, after consulting with counties and municipalities (road agency/road authority), may set local speed restrictions on stretches of road with many residences exposed to noise nuisance.

9. The catalogue of the effect and cost of various tools in the Road-Noise Strategy should be distributed to municipalities and counties.

10. Stock will be taken of the ongoing noise-abatement initiatives every five years in connection with the EU Noise Directive. This will form the basis for assessing the need to adjust the Strategy.

The total effect of the initiatives is hard to assess, as the effect will depend on the political and financial decisions made by counties, municipalities, and private individuals regarding noise protection in future years.

However, it is certain that there will be an effect from the continuing state efforts to encourage the EU to secure quieter tyres and vehicles (initiative 1), and this will lead to a reduction of about 10 per cent in the number of residences exposed to severe noise nuisance by 2020. According to estimates, the improved noise protection from the extension of the state roads in the Government's investment plan (initiative 3) will reduce the number of residences exposed to severe noise nuisance along state roads by 15-20 per cent, corresponding to a reduction in the total number of residences exposed to severe noise nuisance nationally of about 1 per cent.

Public information about the possibilities of using quieter tyres (initiative 2) could reduce the number of residences exposed to noise nuisance by about 3 per cent, provided half of all vehicles are fitted with quieter tyres by 2020. Informing about the possibility of changing to energy and noise reducing windows (initiative 4) could potentially have a great effect, if the good results from having property owners change to energy-efficient windows were able to include changing to noise reducing windows in the long term. Using the tool of imposing a speed limit (initiative 9), a good dB return can be achieved cheaply on many of the stretches of road with residences exposed to noise nuisance.

A central tool in future efforts to reduce noise could be the use of quieter asphalt surfacing. The state initiatives 5 and 6 aim at ensuring that, from a technical perspective, the road authorities are able to do this very quickly. A lot of experience indicates that the cheapest noise-reducing asphalt (with an effect of 1.5-2 dB) can be used at a modest extra cost compared with "standard" asphalt.

The background and objectives of the individual initiatives are explained in more detail below.

1. **Danish efforts within the EU cooperation to tighten the requirements regarding exposure to noise from vehicles and tyres should be enhanced.**

Denmark has contributed to reducing noise transmitted from cars through ever-tighter EU requirements. As part of the new EU Noise Directive, the Commission will present a proposal for stricter requirements on sources of noise, including noise from cars, no later than 2006.

The Road-Noise Strategy assesses the potential reduction from this tool at 1 dB by 2020. Theoretically, the technical potential is actually greater than 1 dB, and the tool requires no public funding.

The state will endeavour to achieve the best possible results through work within the EU to tighten EU requirements regarding noise from cars.

The effect of EU regulation of vehicles and tyres can be expected to be a reduction of about 10 per cent in the number of residences exposed to severe noise nuisance by 2020.

2. **Consumers should be informed of the possibility of changing to quieter tyres.**

Although the EU Tyre Directive of 2002 means some improvement in the noise properties of tyres, there is considerable technical potential for further reductions in the noise from tyres in Denmark, if quieter tyres become more widespread.

The state will enter into dialogue with the tyre industry to promote the use of ecolabelled tyres. From 2007, there will be a technical basis for implementing more widespread consumer information on the noise properties of a considerable number of tyres on the Danish market. If consumer information does not encourage enough consumers to choose quieter tyres, in around 2010 there will be a study of whether it is possible to promote the use of quieter tyres further through differential taxes that favour quieter tyres, taking into account the stop on tax increases.

When a possible differential tax is introduced, it will be vital to set up a clear, objective tax basis. Assessments indicate that such a basis will not exist before the results of the EU Tyre Directive are known in around 2010.

However, efforts to promote awareness of eco-labelled tyres (with the Swan label) can be commenced immediately. Estimates indicate that there will be an adequate basis to implement more widespread information about a greater range of tyres on the market from 2007 with information about the noise properties of individual tyres.

The Road-Noise Group assesses that targeted efforts to promote quieter tyres could realise 33 per cent of the technical potential by 2020, corresponding to having half of all vehicles fitted with quieter tyres. This on its own will provide a reduction in overall noise levels of about 3 per cent. Noise will be reduced by 0.1-0.3 dB and a positive trend will have been initiated which, in the longer term, could lead to a complete change to quieter tyres.

3. **The current level of protection in connection with approved and planned traffic investment in the state road network should be retained, and this will contribute towards a significant reduction in noise levels along state roads.**

In connection with building new state roads or extending existing state roads, significant sums are being allocated to noise reduction. For larger extension projects, efforts will include abatement of noise from the extension work itself, as well as existing noise. One example is the extension to the Motorring 3 motorway around Copenhagen where DKK 190 million (about 10 per cent of the total construction budget) is expected to be spent on noise abatement.

Traffic investments in progress and investments approved, together with the proposed state investment plan for new traffic investment, cover a total of 20 road projects of varying size, and realisation of these will contribute to reducing noise nuisance along the state roads. It is estimated that the projects in the investment plan will lead to a reduction of about 1 per cent in the total residences exposed to noise nuisance. The effect on the noise impact along the state road network is estimated at between 15 and 20 per cent.

4. **The possibility of changing to windows with noise-absorbing and energy-saving properties should be included in future activities for energy-efficient windows to be conducted in cooperation with the glazing sector.**

In connection with an agreement with the glazing sector and associated campaigns for energy-saving windows, the state will convey the message that "combi-windows" with both noise and energy-reducing properties can be a good alternative for housing along busy roads.

As part of these campaigns, information materials could be prepared for municipalities, urban renewal companies, and housing associations to inform about the opportunities to use noise-reducing windows in housing renovation and urban renewal projects.

The Danish Energy Authority has had good experience with such campaigns for energy-saving windows over a number of years and today more than 50 per cent of all windows have good energy-saving properties. Similar results could be achieved in the long term for noise-reducing windows in residences exposed to noise nuisance.

5. **As documentation for noise-reducing road surfaces becomes available, information activities on the effect of different types of noise-reducing road surfaces should be enhanced with a view to creating a better decision-base for road authorities to use this tool.**

In recent years, there has been increasing focus on the development of new noise-reducing thin-layer surfacing that today is assessed to have a smaller noise-reducing effect than drain asphalt, but is only slightly more expensive than normal surfacing and thus can be realised at relatively low cost.

Possible replacement with noise-reducing surfacing should ideally take place at the same time as the wearing course would need replacing anyway in order to minimise financing requirements.

On the basis of current trials with double-course drain asphalt by the City of Copenhagen and the new types of noise-reducing thin-layer surfacing in Copenhagen, Århus and Randers municipalities, the Danish Road Directorate will examine the effect of noise-reducing road surfacing. As documentation for noise-reducing road surfaces becomes available, the state will enhance information activities on the effect of different types of noise-reducing road surfacing.

The Road Directorate is preparing a status report on the stretches of state roads needing noise-reducing surfacing. At the same time, a technical and economic analysis will be completed of the possible use of quieter road surfacing on Motorring 3.

Furthermore, the Danish Road Directorate will assess whether there are grounds to prepare actual type approvals for quieter road surfaces, with specific requirements for the surfacing.

6. **In connection with the ongoing replacement of asphalt surfacing on state roads, in light of the documentation at hand and the given construction and operating budgets, there should be assessments of whether there are grounds for using noise-reducing road surfaces.**

The surfacing previously used on the state road network has usually been more noisy than the types of surfacing used today.

As documentation for the noise-abatement effects and costs of construction and operation of the new types of surfacing becomes available, there will be assessments of whether it is economically and technically feasible within the

existing framework to make further use of noise-reducing surfacing, for example thin-layer surfacing.

7. **The guidelines on road noise in residential areas should be updated to account for both the Road-Noise Strategy and the EU Directive on noise.**

Efforts by the authorities over the past 15-20 years have concentrated on ensuring that new housing is not built with noise nuisances exceeding the limit value of 55 dB. This is in accordance with provisions in the Danish Planning Act and Byggeloven ('the Building Act'), both of which have applied since the early 1980s. New residential areas cannot be laid out where noise nuisance from road traffic exceeds 55 dB, and for housing construction in existing urban areas traffic noise may only be a maximum of 55 dB at the facade, or 30 dB indoors.

When constructing new roads, as a point of departure all endeavours will be made to keep to the limit value of 55 dB.

The 1984 guidelines from the Danish EPA on road traffic noise in residential areas will be updated. There will be studies of whether the guidelines can ensure better protection against road noise for existing housing when new roads are built and in connection with extensions to existing roads.

In this regard, there should be studies to illustrate whether it is appropriate to introduce recommended limit values for existing dwellings in certain planning situations and for noise at night, which must be mapped in accordance with the EU Directive.

8. **Municipalities and counties should be encouraged to be aware that the Danish Road Traffic Act contains provisions that the police, after consulting with counties and municipalities (road agency/road authorities), may set local speed restrictions on stretches of road with many residences exposed to noise nuisance.**

In Denmark today it is possible to impose speed restrictions because of noise considerations. This is in accordance with section 42(5) of the Road Traffic Act. It may be particularly relevant in urban areas. However, it seems to the Road-Noise Group that this possibility is rarely exploited.

Analyses of tools show that speed restrictions are a cheap tool when used in areas with many residences exposed to noise nuisance.

The effect of speed restrictions depends on the original speed and varies from 0.6 dB to 2.1 dB for a reduction of 10 km/hr. The greatest noise-reduction effect can be achieved on roads with speeds of 60-80 km/hr, and thus the tool has great potential for municipal and county roads.

The tool can be realised when the police - following consultation with counties or municipalities - decide to impose a local speed limit on the stretches of road with the greatest noise nuisance. Use of this tool can also harmonise well with local road-safety considerations.

The recommendation is that municipalities and counties should be encouraged to be aware that the Danish Road Traffic Act contains provisions that local speed restrictions can be set on stretches of road with many residences exposed to noise nuisance.

It will be advantageous if municipalities and counties work with the police to prepare guidelines for the decision-process for setting local speed restrictions because of noise concerns.

9. **The catalogue of the effect and cost of various tools in the Road-Noise Strategy should be distributed to municipalities and counties.**

Knowledge of the effect and cost of noise tools as well as the associated combinations of tools described in the Road-Noise Strategy will be disseminated at a conference for counties and municipalities, where the Road-Noise Strategy will be presented, as well as through a possible printed publication.

The conclusions on the effects and costs of the tools will also be a theme in connection with preparation of the action plans required by the Noise Directive.

10. **Stock will be taken of the ongoing noise-abatement initiatives every five years in connection with the EU Noise Directive. This will form the basis for assessing the need to adjust the Strategy.**

Implementation into Danish legislation of the EU Noise Directive, including its requirements on mapping noise sources and preparing action plans on noise, will provide a good opportunity for all authorities to assess technical tools analysed in the Road-Noise Strategy in the prioritised action plans.

Preparation of the status reports of the overall efforts every five years will require regular collection of information regarding mapping of the noise problem and the actual noise-abatement initiatives by counties, municipalities, the state, and the private sector. A number of key indicators will be developed in this connection to best describe developments in the scope of the problem.

Thus, the long-term noise-abatement efforts will continue revolving around the five-year cycle in the Noise Directive.

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Annex 1: The terms of reference for the Road-Noise Group

Objective

The Road-Noise Group has been set up with the purpose of preparing a strategy to limit noise from road traffic (the Road-Noise Strategy), including the carrying out of the necessary interim studies and investigations. In the Strategy, the possibility of achieving the target in Traffic 2005 to limit noise from road traffic is to be emphasised. Another objective is for the Road-Noise Strategy to contribute towards ensuring a good foundation for the implementation of the EU Directive on the Assessment and Management of Environmental Noise (see the attached note regarding this).

The Road-Noise Strategy can be used as a starting point for deciding how any efforts against noise from road traffic can be organised in the future.

The Road-Strategy Group's Members

The Road-Noise Group has participants from the Ministry of Finance, Denmark's Road Safety and Transport Agency, the Ministry of the Environment's National Planning Department, the Environmental Protection Agency, the National Board of Health, the Ministry of Transport, the Danish Road Directorate and the Ministry of Economic and Business Affairs.

The Environmental Protection Agency chairs the Noise-Protection Group and is responsible for the secretariat function.

The content of the Road-Noise Strategy

A proposed strategy for limiting road traffic noise is to be prepared. The new EU Noise Directive and the requirements that appear in the Directive regarding noise mapping, action plans and the publicity strategy are to form the framework for work on the Road-Noise Strategy.

The Strategy is to contain an outline with regard to which and to which extent measures to reduce noise can be used to limit the number of dwellings exposed to severe noise nuisance. The Strategy is not to consist of tangible proposals for solutions for individual roads or streets. There will only be an overall assessment of the potential of the various tools.

Among other things, the proposed Strategy is to contain:

- a summary account of the health impacts from noise from road traffic and an assessment of the economic consequences of this.
- An assessment of tools for reducing noise from road traffic, including an assessment of the interaction between tools, the noise-reducing effects of the tools and typical unit costs associated with the tools.
- An assessment of whether there is a need to give those actors that can realise the objectives of reducing the present noise from road traffic a change in powers and whether there is a need to develop new tools.
- Provide proposals for the financing of the expenditure associated with the achieving of the Strategy's goals.

The reports, assessments, analyses etc. included in the proposed Strategy are to be based on existing knowledge.

Timetable

The Road-Noise Group's report is to be available at the start of 2003, after which the Road-Noise Group's proposed Strategy will be circulated for comment.

Footnotes

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft1#ft1" __[1]_ Reproduced in accordance with Miedema, H.M.E.: "Annoyance from transportation noise: relationship with exposure metrics DNL and DENL and their confidence intervals", Environmental Health Perspectives 109 (6) 2001 pp. 409 - 416.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft2#ft2" __[2]_ Directive 2001/43/EC amending the tyre directive 92/23/EEC and introduced in Denmark through regulation of 22 July 2002.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft3#ft3" __[3]_ EU Directive 2002/49 on the Assessment and Management of Environmental Noise, coming into force on 18 July 2002.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft4#ft4" __[4]_ Bistrup ML.ed.: Health effects of noise on children and perception of the risk of noise. National Institute of Public Health (Statens Institut for Folkesundhed), Denmark, 2001.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft5#ft5" __[5]_ Miedema 2000.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft6#ft6" __[6]_ Klaebo 2001.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft7#ft7" __[7]_ Environmental factors in the day-to-day lives of Danes – with special focus on the housing environment. The National Institute of Public Health, 2003. It should be emphasised that this study did not focus on annoyance from traffic noise, and it was only annoyance in the dwelling within the last 14 days that was asked about.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft8#ft8" __[8]_ The Environmental Protection Agency, 2003: What is the cost of noise? Environmental report no. 795, 2003.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft9#ft9" __[9]_ Presumably, buyers will be first and foremost interested in whether a house faces the road and here it is not necessarily only road noise that is of importance but also the roads effect as a barrier in the landscape, increased air pollution and the view of the road. In the Environmental Protection Agency’s study, it has been attempted to uncover whether factors other than noise should be included as an explanatory variable in the model. It is therefore conceivable that buyers, instead of a direct noise variable, react to a greater extent to the distance to the road. This has been tested in two different models and in both cases it has not been possible to demonstrate that the distance variable is significant in the models.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft10#ft10" __[10]_ The total noise exposure figure for all dwellings above 55 dB is to be calculated for the total distribution of dwellings exposed to noise nuisance in 2001. The total noise exposure figure has been calculated at 159,000 for dwellings with noise above 55 dB.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft11#ft11" __[11]_ TÜV Automotive: Determination of the state-of the-art concerning rolling noise, rolling-resistance and safety properties of modern car tyres". July 2003, and: Delta: “Calculation of the

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_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft14#ft14" __[14]_ The degree of distribution for the individual tools is gone through in Chapter 4.

_ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "ft15#ft15" __[15]_ Interim report on Noise, Health and Nuisance

| _ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/ren.htm" \l "DOCTOP#DOCTOP" __Til Top_ | | _ HYPERLINK "http://www.mst.dk/udgiv/publikationer/2003/87-7614-072-5/html/default.htm" __Forside_ |

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