COMPETITIVE AND SUSTAINABLE GROWTH (GROWTH) PROGRAMME

UNITE

UNIfication of accounts and

marginal costs for Transport Efficiency

Deliverable 11, Appendix

Marginal Cost Case Study 9b: Heavy Goods Vehicle for Finland

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Table of Contents

Executive Summary

This case study analyses the marginal environmental costs (direct and indirect emission and noise) of a modern heavy goods vehicle traveling from sub-urban Helsinki along an inter-urban highway to sub-urban Turku (a trip of 160 km). Marginal costs mean the environmental costs caused by an additional vehicle driving on a certain route.

Estimation of the marginal costs is based on the Impact Pathway Method. Emission costs are estimated by using the *EcoSense* computer model. Noise costs are estimated by using a model specifically developed for this project.

The results show, that the total marginal emission costs per vehicle kilometer are in the range of €cent 5.5 – 8.8 per vehicle kilometer, depending on the vehicle weight and emission norm, and the time of day for noise cost. If the impacts of the fuel chain are allocated to vehicle-km, the marginal emission costs rise by 10 %.

Global warming and noise costs at urban segments of the route are the most significant marginal environmental costs. Local health impacts are also of significance. In an inter-urban environment, global warming and health impacts due to local and regional pollutants are the most significant marginal costs.

During the coldest winter days, preheating of the engines with marginal electricity produced by reserve power plants, often coal fired, causes additional indirect emissions costs of approximately €cent 5 per start.

The results are subject to uncertainty, most importantly concerning the value used for estimating the impacts of global warming, and the methodology as well as end point values used for estimating the marginal costs of noise. The damage cost estimates of global warming vary significantly by source study, whereas the methodology used for estimating marginal noise costs is new specifically developed for UNITE, and is likely to be revised in the future.

The results on emission costs can be generalized and used for representing the approximate marginal cost best at inter-urban locations where the average HGV technology is of the EUROII and EUROIII norm levels, and the population density corresponds with the rural densities of Finland. The results for the maximum permissible weight of 42 tonnes, applies to other European countries except Finland and Sweden, where also the results for the maximum weight of 60 tonnes apply.

The noise costs apply for heavy goods vehicles at locations where traffic volumes and the number of noise receptors are identical to urban/sub-urban Helsinki. Amenity (property) value is however, is a site dependent issue, which must be taken into account in generalization. Purchasing power adjustments are needed for performing benefit transfers from Finland to other countries.

B.1 Introduction

This case study estimates the marginal emission and noise costs caused by the movement of a single heavy goods vehicle (HGV) both in an urban and inter-urban environment. Estimation of the marginal costs is based on the Impact Pathway Method. Emission costs are estimated by using the *EcoSense* computer model. Noise costs are estimated by using a model specifically developed for this project. Noise cost assessment is limited only to the urban route segment of the case study in Helsinki.

The case study analyses a single trip of a four-axle HGV with a maximum permissible weight of both 42 and 60 tons on highway E18 from Helsinki to Turku, with suburban segments to terminal areas at both ends of the route. The total weight of 42 tons represents a maximum for most European countries, while in the Nordic countries a 60 tons maximum total weight is permitted.

Both a standard EUROII and a EUROIII norm HGV with respect to fuel (diesel) quality, engine technology and emission abatement technology are analysed. As a Nordic feature, the additional costs of indirect emissions due to electrical preheating of the engine at wintertime are also considered.

The analysis of marginal emission costs is made at Electrowatt-Ekono Oy with the *EcoSense* model, methodologically supported by IER at the University of Stuttgart. For estimating marginal noise cost, input data has been supplied by Electrowatt-Ekono Oy to IER for making the actual calculations. The tools for estimating both marginal emission costs and marginal noise costs have been developed by IER.

The methodological background of marginal emission cost estimation can be examined in closer detail in European Commission (1999) and Friedrich & Bickel (2001). The methodology on marginal noise cost estimation is discussed in closer detail in Metroeconomica (2001).

B.2 Description of case study

B.2.1 Location

The case study route is part of the main transport corridor (highway E18) on the west to east axis of southern Finland, connecting Turku, a port city in southwest Finland, and the capital Helsinki (Figure B-1). From Helsinki to the east, the E18 corridor continues to the Vaalimaa border crossing connecting Finnish and Russian road networks. At the Finnish west end point, the corridor is connected to Swedish networks by a ferry link (Turku – Stockholm). Thus, the corridor serves both national and international traffic flows, and it is a part of the TEN-networks, as well as the so-called Nordic Triangle.

Specific details:

- The length of the route is 160 km. The duration of the trip is 2 hours at the average speed of 80 km/h.
- The link is a motorway, with four lanes in the proximity of Helsinki and Turku (approximately 25 km at both ends), and with two lanes on other sections.
- The terrain is relatively flat, with minor sloping at some segments.
- The passage is located in an urban/semi-urban environment at both end points. Otherwise, it runs through peripheral areas with low population densities. Some smaller towns and communities are located in the proximity of the route.

Figure B-1. Route of case vehicle from Helsinki to Turku along highway E18.

B.2.2 Methodology

Marginal costs in this case study means the environmental costs caused by an additional vehicle driving on a certain route. For noise costs the time of day is relevant as well, due to the sensitivity of the receptors (which is different at night than during the day) and the high importance of the background noise level for the results.

This approach of looking at the impacts of one additional vehicle requires a detailed bottom-up approach as it has been developed in the ExternE project series. The methodology follows as far as possible this Impact Pathway Approach, which is described in the following sections. For more detailed information see European Commission (1999a and 1999b), Friedrich and Bickel (2001).

B.2.2.1 Air Pollution

The starting point for the bottom-up approach for quantification of marginal costs is the micro level, i.e. the traffic flow on a particular route segment. Then, the marginal external costs of one additional vehicle are calculated for a single trip on this route segment. This is made by modelling the path from emissions to impacts and the respective costs. Results of recent bottom-up calculations have shown that the value of externalities may differ substantially from one transport route to another (see e.g. Friedrich and Bickel 2001).

For quantifying the costs due to airborne pollutants the Impact Pathway Approach was applied. It comprises the steps:

– emission calculation,
– dispersion and chemical conversion modelling,
– calculation of physical impacts, and
– monetary valuation of these impacts.

These steps are described in more detail in the following sections.

Emissions/burdens

In the first step the emissions from an additional vehicle on a specific route are calculated.

For comparisons between modes, the system boundaries considered are very important. For instance, when comparing externalities of goods transport by electric trains and heavy-duty road vehicles, the complete chain of fuel provision has to be considered for both modes. Obviously, it makes no sense to treat electric trains as having no airborne emissions from operation. Instead, the complete chain from coal, crude oil, etc. extraction up to the fuel or electricity consumption has to be taken into account.

Concentrations

To obtain marginal external costs, the changes in the concentration and deposition of primary and secondary pollutants due to the additional emissions caused by the additional vehicle have to be calculated. The relation between emission and concentration of pollutants are highly non-linear for some species (e.g. primary particles). So, air quality models that simulate the transport as well as the chemical transformation of pollutants in the atmosphere are used.

Depending on the range and type of pollutant considered different models are applied: The Gaussian dispersion model ROADPOL for calculation of pollutant concentrations from line sources on the local scale up to 25 km from the road (Vossiniotis et al. 1996); the Wind rose Trajectory Model (WTM) is used to quantify the concentration and deposition of non-reactive pollutants and acid species on a European scale (Trukenmüller and Friedrich 1995); the Source-Receptor Ozone Model (SROM), which is based on source-receptor (S-R) relationships from the EMEP MSC-W oxidant model for five years of meteorology (Simpson et al. 1997), is used to estimate changes in ozone concentrations on a European scale.

Impacts

Concentrations then translate into impacts through the application of exposure-response functions, which relate changes in human health, material corrosion, crop yields etc. to unit changes in ambient concentrations of pollutants.

Exposure-response functions come in a variety of functional forms. They may be linear or non-linear and contain thresholds (e.g. critical loads) or not. Those describing effects of various air pollutants on agriculture have proved to be particularly complex, incorporating both positive and negative effects, because of the potential for certain pollutants, e. g. those containing sulphur and nitrogen, to act as fertilisers.

The dose-response functions used within UNITE are the final recommendations of the expert groups in the final phase of the ExternE Core/Transport project (Friedrich and Bickel 2001). Table B-1 gives a summary of the dose-response functions as they are implemented in the EcoSense version used for this study.

Table B-1
Health and environmental effects included in the analysis of air pollution costs

Impact category	Pollutant	Effects included
Public health – mortality	$PM_{2.5}$, PM_{10} [1)] SO_2, O_3	Reduction in life expectancy due to acute and chronic mortality Reduction in life expectancy due to acute mortality
Public health – morbidity	$PM_{2.5}$, PM_{10}, O_3	respiratory hospital admissions restricted activity days
	$PM_{2.5}$, PM_{10} only	cerebrovascular hospital admissions congestive heart failure cases of bronchodilator usage cases of chronic bronchitis cases of chronic cough in children cough in asthmatics lower respiratory symptoms
	O_3 only	asthma attacks symptom days
Material damage	SO_2, acid deposition	Ageing of galvanised steel, limestone, natural stone, mortar, sandstone, paint, rendering, zinc
Crops	SO_2	Yield change for wheat, barley, rye, oats, potato, sugar beet
	O_3	Yield loss for wheat, potato, rice, rye, oats, tobacco, barley, wheat
	Acid deposition	increased need for liming
	N, S	fertiliser effects

[1)] including secondary particles (sulphate and nitrate aerosols).

Source: IER

Impacts on human health

Table B-2 lists the exposure response functions used for the assessment of health effects. The exposure response functions are taken from the 2nd edition of the ExternE Methodology report (European Commission 1999a), with some modifications resulting from recent recommendations of the health experts in the final phase of the ExternE Core/ Transport project (Friedrich and Bickel 2001).

Table B-2
Quantification of human health impacts due to air pollution[1)]

Receptor	Impact Category	Reference	Pollutant	f_{er}
ASTHMATICS (3.5% of population)				
Adults	Bronchodilator usage	Dusseldorp et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.163 0.163 0.272 0.272
	Cough	Dusseldorp et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.168 0.168 0.280 0.280
	Lower respiratory symptoms (wheeze)	Dusseldorp et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.061 0.061 0.101 0.101
Children	Bronchodilator usage	Roemer et al., 1993	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.078 0.078 0.129 0.129
	Cough	Pope and Dockery, 1992	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.133 0.133 0.223 0.223
	Lower respiratory symptoms (wheeze)	Roemer et al., 1993	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.103 0.103 0.172 0.172
All	Asthma attacks (AA)	Whittemore and Korn, 1980	O_3	4.29E-3
ELDERLY 65+ (14% of population)				
	Congestive heart failure	Schwartz and Morris, 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates CO	1.85E-5 1.85E-5 3.09E-5 3.09E-5 5.55E-7
CHILDREN (20% of population)				
	Chronic cough	Dockery et al., 1989	PM_{10} Nitrates $PM_{2.5}$ Sulphates	2.07E-3 2.07E-3 3.46E-3 3.46E-3
ADULTS (80% of population)				
	Restricted activity days (RAD)	Ostro, 1987	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.025 0.025 0.042 0.042
	Minor restricted activity days (MRAD)	Ostro and Rothschild, 1989	O_3	9.76E-3
	Chronic bronchitis	Abbey et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates	2.45E-5 2.45E-5 3.9E-5 3.9E-5
ENTIRE POPULATION				
	Chronic Mortality (CM)	Pope et al., 1995	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.129% 0.129% 0.214% 0.214%
	Respiratory hospital admissions (RHA)	Dab et al., 1996	PM_{10} Nitrates $PM_{2.5}$ Sulphates	2.07E-6 2.07E-6 3.46E-6 3.46E-6
		Ponce de Leon, 1996	SO_2 O_3	2.04E-6 3.54E-6
	Cerebrovascular hospital admissions	Wordley et al., 1997	PM_{10} Nitrates $PM_{2.5}$ Sulphates	5.04E-6 5.04E-6 8.42E-6 8.42E-6
	Symptom days	Krupnick et al., 1990	O_3	0.033
	Cancer risk estimates	Pilkington et al., 1997; based on US EPA evaluations	Benzene Benzo-[a]-Pyrene 1,3-buta-diene Diesel particles	1.14E-7 1.43E-3 4.29E-6 4.86E-7
	Acute Mortality (AM)	Spix et al. / Verhoeff et al.,1996	PM_{10} Nitrates $PM_{2.5}$ Sulphates	0.040% 0.040% 0.068% 0.068%
		Anderson et al. / Touloumi et al., 1996	SO_2	0.072%
		Sunyer et al., 1996	O_3	0.059%

[1)] The exposure response slope, f_{er}, has units of [cases/(yr-person-µg/m^3)] for morbidity, and [%change in annual mortality rate/(µg/m^3)] for mortality. Concentrations of SO_2, PM_{10} , PM_{10}, sulphates and nitrates as annual mean concentration, concentration of ozone as seasonal 6-h average concentration.

Source: Friedrich and Bickel 2001

Impacts on building materials

Impacts on building material were assessed using the most recent exposure-response functions developed in the last phase of the ExternE Core/Transport project (Friedrich and Bickel 2001). This work includes the latest results of the UN ECE International Co-operative Programme on Effects on Materials (ICP Materials) for degradation of materials, based on the results of an extensive 8-year field exposure programme that involved 39 exposure sites in 12 European countries, the United States and Canada (Tidblad et al. 1998).

Limestone:

maintenance frequency: $1/t = [\ (2.7[SO_2]^{0.48}e^{-0.018T} + 0.019Rain[H^+])/R\ ]^{1/0.96}$

Sandstone, natural stone, mortar, rendering:

maintenance frequency: $1/t = [\ (2.0[SO_2]^{0.52}e^{f(T)} + 0.028Rain[H^+])/R\ ]^{1/0.91}$

f(T) $f(T) = 0$ if $T < 10\ ^oC$; $f(T) = -0.013(T-10)$ if $T \geq 10\ ^oC$

Zinc and galvanised steel:

maintenance frequency: $1/t = 0.14[SO_2]^{0.26}e^{0.021Rh}e^{f(T)}/R^{1.18} + 0.0041Rain[H^+]/R$

f(T) $f(T) = 0.073(T-10)$ if $T < 10\ ^oC$; $f(T) = -0.025(T-10)$ if $T \geq 10\ ^oC$

Paint on steel:

maintenance frequency: $1/t = [\ (0.033[SO_2] + 0.013Rh + f(T) + 0.0013Rain[H^+])/5\ ]^{1/0.41}$

f(T) $f(T) = 0.015(T-10)$ if $T < 10\ ^oC$; $f(T) = -0.15(T-10)$ if $T > 10\ ^oC$

Paint on galvanised steel:

maintenance frequency:

$1/t = [\ (0.0084[SO_2] + 0.015Rh + f(T) + 0.00082Rain[H^+])/5\ ]^{1/0.43}$

f(T) $f(T) = 0.04(T-10)$ if $T < 10\ ^oC$; $f(T) = -0.064(T-10)$ if $T \geq 10\ ^oC$

Carbonate paint:

maintenance frequency: $$1/t = 0.12 \cdot \left(1 - e^{\frac{-0.121 \cdot Rh}{100 - Rh}}\right) \cdot [SO_2] + 0.0174 \cdot [H^+] \Big/ R$$

with	*1/t*	*maintenance frequency in 1/a*
	$[SO_2]$	SO_2 *concentration in* $\mu g/m^3$
	T	*temperature in* ^oC
	Rain	*precipitation in mm/a*
	[H+]	*hydrogen ion concentration in precipitation in mg/l*
	R	*surface recession in* μm
	Rh	*relative humidity in %*

Impacts on crops

Effects from SO2

For the assessment of effects from SO_2 on crops, an adapted function from the one suggested by Baker et al. (1986) is used as recommended in ExternE (European Commission 1999c). The function assumes that yield will increase with SO_2 from 0 to 6.8 ppb, and decline thereafter. The function is used to quantify changes in crop yield for wheat, barley, potato, sugar beet, and oats. The function is defined as

$$y = 0.74 \cdot C_{SO2} - 0.55 \cdot (C_{SO2})^2 \qquad \text{for } 0 < C_{SO2} < 13.6 \text{ ppb}$$
$$y = -0.69 \cdot C_{SO2} + 9.35 \qquad \text{for } C_{SO2} > 13.6 \text{ ppb}$$

with y = relative yield change
C_{SO2} = SO_2-concentration in ppb

Effects from ozone

For the assessment of ozone impacts, a linear relation between yield loss and the AOT 40 value (Accumulated Ozone concentration above Threshold 40 ppb) is assumed. The relative yield loss is calculated by using the following equation, and the sensitivity factors given in Table B-3:

$$y = 99.7 - \alpha \cdot C_{O3}$$

with y = relative yield change
α = sensitivity factors
C_{O3} = AOT 40 in ppmh

Table B-3: Sensitivity factors for different crop species

Sensitivity	α	Crop species
Slightly sensitive	0.85	rye, oats, rice
Sensitive	1.7	wheat, barley, potato, sunflower
Very sensitive	3.4	tobacco

Acidification of agricultural soils

The amount of lime required to balance acid inputs on agricultural soils across Europe will be assessed. The analysis of liming needs should be restricted to non-calcareous soils. The additional lime requirement is calculated as:

$$\Delta L = 50 \cdot A \cdot \Delta D_A$$

with ΔL = additional lime requirement in kg/year
A = agricultural area in ha
ΔD_A = annual acid deposition in meq/m^2/year

Fertilisational effects of nitrogen deposition

Nitrogen is an essential plant nutrient, applied by farmers in large quantity to their crops. The deposition of oxidised nitrogen to agricultural soils is thus beneficial (assuming that the dosage of any fertiliser applied by the farmer is not excessive). The reduction in fertiliser requirement is calculated as:

$$\Delta F = 14.0067 \cdot A \cdot \Delta D_N$$

with ΔF = reduction in fertiliser requirement in kg/year
A = agricultural area in ha
ΔD_N = annual nitrogen deposition in meq/m^2/year

B.2.2.2 Discussion of uncertainties

In spite of considerable progress made in recent years the quantification and valuation of environmental damage is still linked to significant uncertainty. This is the case for the Impact Pathway Methodology as well as for any other approach. While the basic assumptions underlying the work in ExternE are discussed in detail in (European Commission 1999a), below an indication of the uncertainty of the results is given as well as the sensitivity to some of the key assumptions.

Within ExternE, Rabl and Spadaro (1999) made an attempt to quantify the statistical uncertainty of the damage estimates, taking into account uncertainties resulting from all steps of the impact pathway, i.e. the quantification of emissions, air quality modelling, dose-effect modelling, and valuation. They show that - due to the multiplicative nature of the impact pathway analysis - the distribution of results is likely to be approximately lognormal, thus it is determined by its geometric mean and the geometric standard deviation σ_g.

In ExternE, uncertainties are reported by using uncertainty labels, which can be used to make a meaningful distinction between different levels of confidence, but at the same time do not give a false sense of precision, which seems to be unjustified in view of the need to use subjective judgement to compensate the lack of information about sources of uncertainty and probability distributions (Rabl and Spadaro 1999).

The uncertainty labels are:

A = high confidence, corresponding to σ_g = 2.5 to 4;
B = medium confidence, corresponding to σ_g = 4 to 6;
C = low confidence, corresponding to σ_g = 6 to 12.

According to ExternE recommendations, the following uncertainty labels are used to characterise the impact categories addressed in this report:

Mortality:	B
Morbidity:	A
Crop losses:	A
Material damage:	B.

Beside the statistical uncertainty indicated by these uncertainty labels, there is however a remaining systematic uncertainty arising from a lack of knowledge, and value choices that influence the results. Some of the most important assumptions and their implications for the results are briefly discussed in the following.

- **Effects of particles on human health**
  The dose-response models used in the analysis are based on results from epidemiological studies, which have established a statistical relationship between the mass concentration of particles and various health effects. However, at present it is still not known whether it is the number of particles, their mass concentration or their chemical composition, which is the driving force. The uncertainty resulting from this lack of knowledge is difficult to estimate.
- **Effects of nitrate aerosols on health**
  We treat nitrate aerosols as a component of particulate matter, which we know cause damage to human health. However, in contrast to sulphate aerosol (but similar to many other particulate matter compounds) there is no direct epidemiological evidence supporting the harmfulness of nitrate aerosols, which partly are neutral and soluble.
- **Valuation of mortality**
  While ExternE recommends using the Value of a Life Year Lost *rather than the* Value of Statistical Life *for the valuation of increased mortality risks from air pollution (see European Commission 1999a for a detailed discussion), this approach is still controversially discussed in the literature. The main problem for the* Value of a Life Year Lost *approach is that up to now there is a lack of empirical studies supporting this valuation approach.*
- **Impacts from ozone**
  As the EMEP ozone model, which is the basis for the Source-Receptor Ozone Model (SROM) included in EcoSense does not cover the full EcoSense modelling domain, some of the ozone effects in Eastern Europe are omitted. As effects from ozone are small compared to those from other pollutants, the resulting error is expected to be small compared to the overall uncertainties.
- **Omission of effects**
  The present report is limited to the analysis of impacts that have shown to result in major damage costs in previous ExternE studies. Impacts on e.g. change in biodiversity, potential effects of chronic exposure to ozone, cultural monuments, direct and indirect economic effects of change in forest productivity, fishery performance, and so forth, are omitted because they currently cannot be quantified.

EcoSense model

EcoSense is a standardised integrated computer model developed for the assessment of environmental impacts and resulting external costs of emissions from transport and energy generation systems.[1] It is a computer version of alternatively applying the Impact Pathway Method by separate dispersion modelling and spreadsheet calculations of impacts.

[1] EcoSense. User Guide. Version 2.0. Institut fur Energiewirtschaft und Rationelle Energieanwendung. (IER). Universität Stuttgart.

EcoSense can assess the impacts of small 'doses' of emissions created by the movement of a single vehicle, and the resulting rise in pollutant concentrations. This coincides with the principle of assessing the marginal cost of vehicle movement. *EcoSense* has separate line and point source models for assessing mobile and stationary sources of pollutants, vehicles, energy production plants and industrial objects respectively. In this case study the line source model is used.

EcoSense provides relevant meteorological data, dispersion models, receptor data, dose-response functions and unit values for damages, all required for an integrated impact assessment related to airborne pollutants. Only a small set of site and case specific input data is required to be added by the user, namely emission characteristics of the vehicle and route trajectory for the line source model.

EcoSense analyses local and regional impacts separately according to the dispersion and damage characteristics of each pollutant. The environmental impacts assessed include health impacts, damage to forest and crop growth, material damage and climate change.

B.2.2.3 Global Warming

The method of calculating costs of CO_2 emissions basically consists of multiplying the amount of CO_2 emitted by a cost factor. Due to the global scale of the damage caused, there is no difference how and where the emissions take place.

A European average shadow value of €20 per tonne of CO_2 emitted was used for valuing CO_2 emissions. This value represents a central estimate of the range of values for meeting the Kyoto targets in 2010 in the EU based on estimates by Capros and Mantzos (2000). They report a value of €5 per tonne of CO_2 avoided for reaching the Kyoto targets for the EU, assuming a full trade flexibility scheme involving all regions of the world.

For the case that no trading of CO_2 emissions with countries outside the EU is permitted, they calculate a value of €38 per tonne of CO_2 avoided. It is assumed that measures for a reduction in CO2 emissions are taken in a cost effective way. This implies that reduction targets are not set per sector, but that the cheapest measures are implemented, no matter in which sector.

Looking further into the future, more stringent reductions than the Kyoto aims are assumed to be necessary to reach sustainability. Based on a reduction target of 50% in 2030 compared to 1990, INFRAS/IWW (2000) use avoidance costs of € 135 per t of CO_2; however one could argue that this reduction target has not yet been accepted.

A valuation based on the damage cost approach, as e.g. presented by ExternE (Friedrich and Bickel 2001), would result in substantially lower costs. Due to the enormous uncertainties involved in the estimation process, such values have to be used very cautiously.

B.2.2.4 Noise

The Impact Pathway Method is applied also for assessing the marginal damage costs of noise. IER at the University of Stuttgart has developed a computer model for this purpose (Metroeconomica 2001).

The marginal cost of noise exposure is caused by an additional vehicle in an average hourly traffic flow considered as a mix of different vehicle types. The traffic flow is split into vehicle categories: light duty vehicles, motorcycles, passenger cars, heavyduty vehicles and buses.

Changes in the average hourly flow are assessed in the following periods: day (07:00 – 19:00), evening (19:00 – 23:00), night (23:00 – 07:00) and day aggregate (07:00 – 23:00). The average hourly flow by vehicle mix for the above periods is provided for each homogenous street segment of the case route. In this case study the 9 km route consists of 37 segments.

Exposure by definition considers the inhabitants living in the apartments with facades directly towards each street segment of the route. This means that only the most exposed apartments are assessed, not the ones on side streets. This simplistic choice is made due to the experimental feature of marginal noise cost assessment here.

The harmful impacts of noise exposure include health impacts (myocardinal infarction; fatal/non-fatal, angina pectoris and hypertension), subjectively valued sleeping quality and property values with rent as a proxy indicator.

B.2.2.5 Other effects

Air pollution, global warming and noise represent the most important and relevant cost categories for marginal environmental costs. Costs due to "habitat losses and biodiversity" represent the economic assessment of damages the presence traffic infrastructure and its use is causing to the habitats of rare species, and thus to biodiversity. The costs are mostly related to the separation effects due to the existence of roads, rail tracks, airports and artificial waterways and thus are fixed in the short run. They are not marginal and therefore not relevant for the quantification of marginal costs. The same is true for visual intrusion in urban areas.

Most of the damages to soil and water are expected to be small or not relevant for marginal cost estimation. For instance, solid emissions by tyre, brake and wheels (emission of Cd, Zn, Cu) and infrastructure (PAH, heavy metals) abrasion can be expected to cause only small marginal costs, as well as de-icing agents. For practical reasons these impacts are only considered in the accounts approach, assuming that additional contamination of one car or train takes place within a certain range along road and railway infrastructure and is not important with concern to marginal costs. It is assumed that soil is already contaminated within a certain reach along frequently used roads/railways. The effect of an additional vehicle can therefore be neglected.

Airborne exhaust emissions and their impacts on soil and water (acidification, eutrophication) are relevant, but currently cannot be quantified in monetary terms consistently. The emissions of sulphur dioxide are small from the (diesel) fuels used in motor transport and trains and unlikely to have a significant impact even adjacent to the highest density traffic routes (Friedrich and Bickel 2001). Nitrogen oxides emissions could to some extent contribute to acidification. Particulate nitrogen deposition could act as a fertiliser and contribute to eutrophication. For practical reasons these minor impacts are not considered for the marginal costs approach.

Solid non-recyclable waste resulting from vehicle and infrastructure disposal could be considered in the ideal approach. Yet, large part of the solid waste is recyclable (e.g. metals). Non-recyclable waste is either deposited or burnt in incineration plants. Only deposited waste products (waste not being burnt) has finally an impact on soil (soil sealing and possible contamination) or on groundwater (leaking of the disposal sites). The quantification of these costs is beyond the scope of UNITE and was therefore neglected.

B.2.3 Data

General data for the calculation of costs due to air pollution

Besides the emissions of the transport modes in the different countries, a large number of additional information was required for the cost calculations. This includes data on the receptor distribution, meteorology, and on the background emissions from all sources in all European countries. Such data is available in the computer tool EcoSense's database (table B-4) and is briefly described in the following.

Table B-4
Environmental data in the EcoSense database

	Resolution	Source
Receptor distribution		
Population	administrative units, EMEP 50 grid	EUROSTAT REGIO Database, The Global Demography Project
Production of wheat, barley, sugar beat, potato, oats, rye, rice, tobacco, sunflower	administrative units, EMEP 50 grid	EUROSTAT REGIO Database, FAO Statistical Database
Inventory of natural stone, zinc, galvanized steel, mortar, rendering, paint	administrative units, EMEP 50 grid	Extrapolation based on inventories of some European cities
Meteorological data		
Wind speed	EMEP 50 grid	European Monitoring and Evaluation Programme (EMEP)
Wind direction	EMEP 50 grid	European Monitoring and Evaluation Programme (EMEP)
Precipitation	EMEP 50 grid	European Monitoring and Evaluation Programme (EMEP)
Emissions		
SO_2, NO_x, NH_3, NMVOC, particles	administrative units, EMEP 50 grid	CORINAIR 1994/1990, EMEP 1998 TNO particulate matter inventory (Berdowski et al. 1997)
Source: IER		

Receptor data

- *Population data*

  Population data was taken from the EUROSTAT REGIO database (base year 1996), which provides data on administrative units (NUTS categories). For impact assessment, the receptor data is required in a format compatible with the output of the air quality models. Thus, population data was transferred from the respective administrative units to the 50 x 50 km^2 EMEP grid by using the transfer routine implemented in EcoSense.

- *Crop production*

  The following crop species were considered for impact assessment: barley, oats, potato, rice, rye, sunflower seed, tobacco, and wheat. Data on crop production were again taken from the EUROSTAT REGIO database (base year 1996). For impact assessment, crop production data were transferred from the administrative units to the EMEP 50 x 50 km^2 grid.

- *Material inventory*

  The following types of materials are considered for impact assessment: galvanised steel; limestone; mortar; natural stone; paint; rendering; sandstone; and, zinc. As there is no database available that provides a full inventory of materials, the stock at risk was extrapolated in ExternE from detailed studies carried out in several European cities.

Emission data

As the formation of secondary pollutants such as ozone or secondary particles depends heavily on the availability of precursors in the atmosphere, the *EcoSense* database provides a European wide emission inventory for SO_2, NO_x, NH_3, NMVOC, and particles as an input to air quality modelling. The emission data are disaggregated both sectorally ('Selected Nomenclature for Air Pollution' - SNAP categories) and geographically ('Nomenclature of Territorial Units for Statistics' - NUTS categories).

As far as available, *EcoSense* uses data from the EMEP 1998 emission inventory (Richardson 2000, Vestreng 2000, Vestreng and Støren 2000). Where required, data from the CORINAIR 1994 inventory (http://www.aeat.co.uk/netcen/corinair/94/) and the CORINAIR 1990 inventory (McInnes 1996) are used. For Russia, national average emission data from the LOTOS inventory (Builtjes 1992) were included. Emission data for fine particles are taken from the European particle emission inventory established by Berdowski et al. (1997).

Meteorological data

The Windrose Trajectory Model requires annual average data on wind speed, wind direction, and precipitation as an input. The EcoSense database provides data from the European Monitoring and Evaluation Programme (EMEP) for the base year 1998.

Emission factors

The vehicle analysed is a lorry with trailer fulfilling EUROII and EUROIII emission norms (European Council 1996). The assessment is made both with a 70 % and a 100 % load factor, i.e. the total weight of the vehicle and payload being 42 tonnes and 60 tonnes respectively. The fuel used is assumed to be sulphur free high quality diesel (so-called city-diesel), which is taken into account in the emission factor.

The emission factors now used are presented in tables B-5 and B-6. These factors have been separately adjusted to represent the average Finnish vehicle fleet and circumstances. This includes the additional emissions caused by starting cold engines, considering also starts at different seasons, i.e. the wintertime freezing temperatures without preheating.[2] It should be noted, that the fuel consumption and CO^2 emissions of EUROIII norm engines are higher due to the introduction of emission abatement technology in HGVs.

Table B-5
Emission factors for EUROII and EUROIII norm heavy goods vehicles, with a maximum weight of 42 tonnes

	Emission factors (g/km)	
Pollutant component	**EUROII**	**EUROIII**
CO	0.24	0.19
HC	0.13	0.1
NOx	13	8.5
PM	0.11	0.072
CH_4	0.013	0.011
SO_2	0.011	0.011
CO^2	1199	1230
Source: Mäkelä et al. (2000)		

Table B-6
Emission factors for EUROII and EUROIII norm heavy goods vehicles, with a maximum weight of 60 tonnes

	Emission factors (g/km)	
Pollutant component	**EUROII**	**EUROIII**
CO	0.27	0.22
HC	0.13	0.11
NOx	14	9.3
PM	0.12	0.08
CH_4	0.014	0.011
SO_2	0.013	0.013
CO^2	1320	1354
Source: Mäkelä et al. (2001)		

[2] The emission factors adopted from Mäkelä et al. (2001) are ones that have been specified according to the EURO norm levels, but which include additional finetuning by taking the Finnish circumstances, climate in partcular, into consideration.

Beside the emissions from vehicle operation the emissions due to fuel provision was considered. The emission factors for crude oil extraction, refining and transport of petrol, diesel and kerosene are given in Table B-7.

Table B-7
Emissions caused by fuel production processes in g/kg fuel

Type of fuel	CO_2	PM_{10}	NO_x	SO_2	NMVOC
Petrol	560	0.105	1.10	1.90	1.80
Diesel; Kerosene	400	0.047	0.96	1.40	0.62
Source: PM_{10}: Friedrich and Bickel (2001); other pollutants: IFEU (1999)					

In the winter, it is typical that the engine is preheated prior to start for reducing the unfavourable impacts of cold starts in freezing temperatures (increased engine wear, fuel consumption and emissions). Technically this means that either the engine block or the cooling liquid is heated for a period with a fixed electric heating device attached to the engine.

The additional indirect emission cost of electricity used for preheating is estimated based on the emissions of so-called marginal electricity production from conventional coal fired condensing power plants. This represents the electricity mix and emissions of the coldest winter periods when reserve power stations are in use, in comparison to the emissions of 'average electricity production'. Input data is presented in table B-8. As the monetary weights for the cost of these emissions, the regional environmental costs of pollutants presented in tables B12 – B15 are used.

Table B-8
Input data for the assessment of emission costs due to electrical preheating of the engine

Specifics	
Output of the heater Time used prior to starting the engine Resulting energy use	600 W 4 hours 2.4 kWh
Emission factors of coal based marginal electricity production (g/kWe)	NOx 1.6 SO_2 0.9 PM 0.1 CO_2 840
Sources: Mäkelä 1994, Laurikko 1998, Hämekoski & Anttila 2001	

Population

Population density is at 3 600 people per km^2 in the route section from the terminal area (Metsälä) to the beginning of the Helsinki – Turku motorway E18. In the proximity of the motorway, population density drops significantly to an average of a few hundred people per km^2. At some very sparsely populated sections it is much lower, and higher at some sections passing smaller towns. In Turku, the route ends at a terminal area just outside of the city center. Average population in Turku is 708 inhabitants per km^2.

Noise exposure[3]

Assessment of marginal noise costs for the case study covers the urban part of the route in Helsinki, where the HGV drives from a central terminal area through urban/sub-urban areas, until moving on to the motorway. The motorway part of the route was not considered interesting for noise costs assessment due to low receptor (population) density. In Turku, the terminal area is just outside city limits.

For the assessment of marginal noise cost, detailed traffic data was obtained on the relevant part of the route by segment, hour, speed, and by traffic mix in vehicle categories. An inventory of noise receptors was made for the same route by street section, identifying each building (most exposed facade) on both side of the street, along with details on distance of the building from street, building height and number of households in the building. An assumption on an average of 2,5 residents per apartment was made.

Values used for assessing marginal costs

Monetary values for health impacts

Table B-9 summarizes the monetary values used for valuing the health impacts of air pollution in UNITE. Average European values should be used for air pollution costs for generalization purposes. Country specific values can be calculated from the European averages for any country according to the benefit transfer rules given in Nellthorp et al. (2001).

Table B-9
Monetary values (factor costs, rounded) for health impacts (€$_{1998}$)

Impact	European average	Finland	
Year of life lost (chronic effects)	74 700	76,500	€ per YOLL
Year of life lost (acute effects)	128 500	131,600	€ per YOLL
Chronic bronchitis	137 600	140,900	€ per new case
Cerebrovascular hospital admission	13 900	14,230	€ per case
Respiratory hospital admission	3 610	3,700	€ per case
Congestive heart failure	2 730	2,800	€ per case
Chronic cough in children	200	200	€ per episode
Restricted activity day	100	100	€ per day
Asthma attack	69	71	€ per day
Cough	34	35	€ per day
Minor restricted activity day	34	35	€ per day
Symptom day	34	35	€ per day
Bronchodilator usage	32	33	€ per day
Lower respiratory symptoms	7	7	€ per day

Source: Own calculations based on Friedrich and Bickel (2001) and Nellthorp et al. (2001).

[3] Input data on traffic flows is provided by JP Transplan Oy. Input data on noise receptors is provided by the Finnish Acoustics Centre Ltd.

Unit values for pollutants at local scale

The health related local damage costs by a tonne of pollutant in each pollutant category are presented in tables B-10 and B-11. These values have been used for deriving the marginal cost for local impacts caused by the movement of the case vehicles.

Table B-10
Local (health) costs per tonne of pollutant for the EUROII and EUROIII norm HGV with a maximum weight of 42 tonnes in Helsinki, €$_{1998}$

Health impact/pollutant	€$_{1998}$/tonne EUROII	€$_{1998}$/tonne EUROIII
Morbidity		
- $PM_{2.5}$	2 857	2 857
- SO_2	2.5	2.5
- CO	0.07	0.07
Mortality		
- $PM_{2.5}$	6 683	6 684
- SO_2	236	236

Table B-11
Local (health) costs per tonne of pollutant for the EUROII and EUROIII norm HGV with a maximum weight of 60 tonnes in Helsinki, €$_{1998}$

Health impact/pollutant	€$_{1998}$/tonne EUROII	€$_{1998}$/tonne EUROIII
Morbidity		
- $PM_{2.5}$	2 857	2 857
- SO_2	2.5	2.5
- CO	0.07	0.07
Mortality		
- $PM_{2.5}$	6 683	6 684
- SO_2	236	236
Source: Own calculations		

Unit values for pollutants at regional and global scale

Tables B12 – B15 present the unit values used for assessing the costs of regional impacts of each pollutant category. These values are also applied for valuing the impacts of preheating of the engine. In addition, the impact of global warming is valued according to the UNITE convention as 20 euros per tonne by the volume of CO_2 emissions.

Table B-12
Regional costs per tonne of NO_2 in south Finland, €$_{1998}$

	Via nitrates (€$_{1998}$)	Via ozone (€$_{1998}$)	Total (€$_{1998}$)
Crops	-	126	126
Materials	-	-	-
Morbidity	372	112	484
Mortality	856	76	932
Health, total	1228	188	1417
Total	**1228**	**314**	**1542**
Source: IER			

Table B-13
Regional costs per tonne of SO_2 in south Finland €$_{1998}$

	Via SO_2 and sulfates (€$_{1998}$)
Crops	-8
Materials	69
Morbidity	212
Mortality	540
Health, total	752
Total	**813**
Source: IER	

Table B-14
Regional costs per tonne of NMVOC in south Finland, €$_{1998}$

Impact	**Via ozone (€$_{1998}$)**
Crops	90
Materials	-
Morbidity	87
Mortality	59
Health, total	145
Total	**236**
Source: IER	

Table B-15
Regional costs per tonne of $PM_{2.5}$ in south Finland, €$_{1998}$

Impact	**$PM_{2.5}$ (€$_{1998}$)**
Morbidity	848
Mortality	1952
Total	**2800**
Source: IER	

Unit values for noise impacts

Table B-16 presents the European average unit values used for valuing health impacts of noise exposure. For Finland, these values are adjusted according to the benefit transfer rules given in Nellthorp et al. (2001).

Table B-16
Monetary values (factor costs, rounded) for impacts due to noise in Finland (€$_{1998}$)

Impact	Finland
Myocardial infarction (fatal, 7 YOLL)	
Total per case	**535,400**
Myocardial infarction (non-fatal, 8 days in hospital, 24 days at home)	
Medical costs	4,830
Absentee costs	2,880
WTP	15,420
Total per case	**23,130**
Angina pectoris (severe, non-fatal, 5 days in hospital, 15 days at home)	
Medical costs	3,030
Absentee costs	1,800
WTP	9,660
Total per case	**14,500**
Hypertension (hospital treatment, 6 days in hospital, 12 days at home)	
Medical costs	1,870
Absentee costs	1,620
WTP	560
Total per case	**4,050**
Medical costs due to sleep disturbance (per year)	201
Average (net) rent per person per year (basis of calculation of WTP for avoiding amenity losses)	2,173
Sources: Own calculations based on Metroeconomica (2001), Nellthorp et al. (2001) and and Statistics Finland (2001)	

A large number of hedonic pricing studies have been conducted, giving NSDI values (Noise Sensitivity Depreciation Index – the value of the percentage change in the logarithm of house price arising from a unit increase in noise) ranging from 0.08% to 2.22% for road traffic noise.

Soguel (1994) conducted a hedonic pricing study in Switzerland. Rather than using housing prices, the dependent variable was monthly rent, net of charges for heating etc. The coefficient on the noise variable in this study suggested a NSDI of 0.9. This value is similar to the average derived from European studies, and it is now used for the calculations of UNITE.

B.3 Results

Marginal emission costs

The marginal emission costs of the movement of a diesel driven EUROII and EUROIII norm HGV from sub-urban Helsinki along an inter-urban highway to Turku are in the range of €cent 3.9 – €cent 5.0 per vehicle-km (tables B-17 and B-18). The difference in the emission norms as well as payload, are of significance. Global warming is the dominant marginal emission cost, with a share of over 50 %. The marginal emission costs attributing to local and regional health impacts are also significant. The marginal costs of impacts on crops and materials are small.

Table B-17
Marginal emission costs for the EUROII norm HGV in inter-urban traffic, by damage category, €cent$_{1998}$

Impact category	Total weight 42 tonnes		Total weight 60 tonnes	
	Cent/case	**Cent/vkm**	**Cent/case**	**Cent/vkm**
Local impacts				
Morbidity	5.21	0.033	5.7	0.036
Mortality	12.2	0.076	14.4	0.09
Regional impacts				
Crops & material	26.3	0.16	28.3	0.177
Morbidity	102.4	0.64	110.3	0.69
Mortality	197.6	1.23	212.8	1.33
Global warming	383.7	2.40	422.4	2.64
Total	**727.4**	**4.55**	**794.0**	**4.96**

Table B-18
Marginal emission costs for the EUROIII norm HGV in inter-urban traffic, by damage category, €cent$_{1998}$

Impact category	Total weight 42 tonnes		Total weight 60 tonnes	
	Cent/case	**Cent/vkm**	**Cent/case**	**Cent/vkm**
Local impacts				
Morbidity	3.41	0.021	3.79	0.024
Mortality	8.02	0.05	8.91	0.056
Regional impacts				
Crops & material	17.2	0.108	18.8	0.118
Morbidity	67.0	0.419	73.3	0.458
Mortality	129.2	0.808	141.4	0.884
Global warming	393.6	2.46	433.28	2.708
Total	**618.5**	**3.87**	**679.6**	**4.25**

Marginal emission costs of preheating the engine

The preheating of an engine electrically produces a marginal emission cost of €cent 5 per a winter start (Table B-19). The cost depends largely on the assumptions made. The length of the heating period (4 hours) is relatively long, and the electricity used is considered to be of the most polluting kind. These assumptions apply only to the coldest winter days. With an assumption of a shorter heating period and average electricity mix, the cost would be considerably lower.

Table B-19
Regional and global emission costs of marginal electricity production for preheating the engine of a HGV, €cent$_{1998}$ (energy used: 2.4 kWh)

Damage category	**NO_x**	**SO_2**	**PM**	**CO_2**	**Total**
Crops	0.05	0	0	-	0.05
Material	0	0	0	-	0
Morbidity	0.2	0.05	0.02	-	0.27
Mortality	0.4	0.1	0.05	-	0.55
Climate change	-	-	-	2.0	2.0
Total	**0.6**	**0.15**	**0.07**	**2.0**	**4.9**

Marginal emission costs of the fuel production chain

Based on the fuel consumption of the EUROII and EUROIII norm heavy goods vehicles and the emission factors for the fuel chain presented in table B-7, the respective marginal costs have been presented in table B-20. The costs are expressed according to Finnish valuation, although the impacts of the chain take partially place in other countries. The main marginal cost element is, however, global warming (75 %).

Table B-20
Marginal emission costs of the fuel chain, €cent$_{1998}$

	EUROII HGV	**EUROIII HGV**
HGV 42 tonnes	*(fuel consumed: 61 kg)*	*(fuel consumed: 62.6 kg)*
Cent/case	65.8	67.5
Cent/vkm	0.41	0.42
HGV 60 tonnes	*(fuel consumed: 67.1 kg)*	*(fuel consumed: 68.9 kg)*
Cent/case	72.5	74.3
Cent/vkm	0.45	0.46

Marginal noise costs

The marginal noise costs of a HGV in an average daytime flow is €cent 1.58, in an average evening flow €cent 1.62 and in an average nighttime flow €cent 3.86 per vehicle kilometer (Table B-21). The results apply to the sub-urban segments of the case route in Helsinki.

In the daytime flow, amenity losses are the dominant marginal costs, whereas at nighttime sleeping disturbance is significant. It should be noted, that these costs are an average for the whole route, i.e. at some locations the marginal cost may peak well above the average, and at some locations it may be close to zero. Noise impact and its costs are by nature very point specific, depending of the proximity and number of the receptors to the source of street noise.

Table B-21
Marginal noise cost for HGV in Helsinki by time of day and impact category, €cent$_{1998}$

Impact category	- Day - Cent/vkm	- Evening - Cent/vkm	- Night - Cent/vkm
Health effects	0.02	0.05	0.17
Amenity losses	1.56	1.56	
Sleep disturbance			3.69
Total	**1.58**	**1.62**	**3.86**

Summary of marginal environmental costs

The total marginal environmental costs (direct emission costs) of a HGV on route from Helsinki to Turku are approximately €cent 3.7 – 5.0 per vehicle kilometer (Table B-22).

According to the evidence from the route segments in Helsinki, with noise costs taken into consideration in urban sections, the costs are likely to be €cent 5.5 – 6.5 per vehicle kilometer with day and evening noise exposure, and approximately €cent 7.7 – 8.8 per vehicle kilometer with nighttime noise exposure.

At wintertime, the additional indirect emission cost of preheating the engine is up to €cent 5 per one start, with the assumptions of maximum heating period and electricity supplied by marginal coal fired condensing power. The additional cost of the impacts of the fuel chain allocated to vehicle-km are €cent 0.438, which means an approximate 5 % rise in the total marginal cost.

Table B-22
Marginal environmental costs for HGV in southern Finland, €cent$_{1998}$

Impact category	EURO II/ Total weight 42 tonnes Cent/vkm	EURO II/ Total weight 60 tonnes Cent/vkm	EURO III/ Total weight 42 tonnes Cent/vkm	EURO III/ Total weight 60 tonnes Cent/vkm
Direct emissions				
Health	1.98	2.146	1.3	1.42
Crops and material	0.11	0.177	0.108	0.118
Global warming	2.40	2.64	2.46	2.71
Noise (urban environment only)	1.58 – 3.86			
Total	**6.07 – 8.35**	**6.54 – 8.82**	**5.45 – 7.73**	**5.83 – 8.11**
Indirect emissions				
Preheating of engine	4.9 €cent per one start			
Fuel chain (average for EUROII and EUROIII)	70 €cent/case 0.438 €cent/vkm			

B.4 Discussion and conclusions

This case study has analysed the marginal environmental costs (direct and indirect emission and noise) of a modern heavy goods vehicle traveling from sub-urban Helsinki along an inter-urban highway to sub-urban Turku (a trip of 160 km).

The results show, that the total marginal emission costs per vehicle kilometer are in the range of €cent 5.5 – 8.8 per vehicle kilometer, depending on the vehicle weight and emission norm, and the time of day for noise cost. If the impacts of the fuel chain are allocated to vehicle-km, the marginal emission costs rise by 5 %.

Global warming and noise costs at urban segments of the route are the most significant marginal environmental costs. Local health impacts are also of significance. In an inter-urban environment, global warming and health impacts due to local and regional pollutants are the most significant marginal costs.

During the coldest winter days, preheating of the engines with marginal electricity produced by reserve power plants, often coal fired, causes additional indirect emissions costs of approximately €cent 5 per start.

The results are subject to uncertainty, most importantly concerning the value used for estimating the impacts of global warming, and the methodology as well as end point values used for estimating the marginal costs of noise. The damage cost estimates of global warming vary significantly by source study, whereas the methodology used for estimating marginal noise costs is new specifically developed for UNITE, and is likely to be revised in the future.

The results on emission costs can be generalized and used for representing the approximate marginal cost best at inter-urban locations where the average HGV technology is of the EUROII and EUROIII norm levels, and the population density corresponds with the rural densities of Finland. The results for the maximum permissible weight of 42 tonnes, applies to other European countries except Finland and Sweden, where also the results for the maximum weight of 60 tonnes apply.

The noise costs apply for heavy goods vehicles at locations where traffic volumes and the number of noise receptors are identical to urban/sub-urban Helsinki. Amenity (property) value is however, is a site dependent issue, which must be taken into account in generalization. Purchasing power adjustments are needed for performing benefit transfers from Finland to other countries.

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Annex B1. Traffic and receptor data for noise cost assessment

Data on traffic volumes and noise receptors (Tables 1-4) is collected according to the following principles. (Source of data: The City Planning Office, The City of Helsinki.)

Road traffic related data

A**.** Four time periods (Tmp) are distinguished:

Tmp id	Description
30	day: 7:00 – 19:00
31	evening: 19:00 – 23:00
32	night: 23:00 – 7:00
33	day, agg 7:00 – 23:00

B. Vehicle categories (fzk) are distinguished:

Fzk	vehicle type
2	light duty vehicle
5	motorcycles
7	passenger cars
9	heavy duty vehicles
11	busses

C. The number of vehicles per hour within the time periods are given by vehicle categories.

D. The speed of the vehicles are specified by vehicle categories.

E. Information on road surface is needed (in general or per road segment).

Noise propagation and receptor related data

Noise exposure is calculated for each individual receptor point. A receptor point may represent a dwelling or a whole facade as long as attributes don't change. A receptor point is defined on the most exposed facade of a dwelling to the road.

F. Receptor data.

receptor id	
road_id	gives the link between traffic data and receptor point
h_dist	horizontal distance between middle of carriage way and receptor point
recep_height	height of receptor point on dwelling (usually 4.5m, might be different for higher houses)
households	number of households for which the noise level is representative

Also the number of people common for a household in Finland is needed in order to calculate the number of people exposed. For urban case studies, it should be taken into account if the street is in a canyon.

Table 1: Street/road segments - all paved

Street name	Beginning of segment	End of segment	Segment id	length [m]	direction
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	600	both
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	250	south
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	280	south
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	380	north
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	1170	both
Vihdintie	Mannerheimintie	Kauppalantie	6	250	both
Vihdintie	Kauppalantie	Korppaanmäentie	7	160	both
Vihdintie	Korppaanmäentie	Lapinmäentie	8	140	both
Lapinmäentie	Vihdintie	Huopalahdentie	9	700	both
Huopalahdentie	Lapinmäentie	Ulvilantie (southern loop)	10	150	both
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	125	both
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	320	south
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	330	north
Turku motorway	End of middle lane	Helsinki - Espoo border	14	1680	both

Table 2. Number of vehicles per hour (per road segment, time period, vehicle category

Street name	Beginning of segment	End of segment	road id	tmp_id	fzk	vehicles per hour
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	30	2	153
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	30	5	5
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	30	7	904
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	30	9	166
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	30	11	1
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	31	2	42
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	31	5	1
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	31	7	503
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	31	9	39
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	31	11	1
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	32	2	16
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	32	5	0
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	32	7	172
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	32	9	26
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	32	11	1
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	34	2	123
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	34	5	4
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	34	7	772
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	34	9	132
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	34	11	1
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	30	2	99
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	30	5	3
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	30	7	806
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	30	9	120
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	30	11	8
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	31	2	27
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	31	5	1
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	31	7	449
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	31	9	28
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	31	11	7
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	32	2	10
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	32	5	0
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	32	7	153
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	32	9	19
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	32	11	1
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	34	2	79
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	34	5	2
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	34	7	689
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	34	9	95
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	34	11	7
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	30	2	15
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	30	5	0
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	30	7	123
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	30	9	10
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	30	11	22
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	31	2	4
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	31	5	0
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	31	7	68
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	31	9	2

Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	31	11	17
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	32	2	2
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	32	5	0
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	32	7	23
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	32	9	2
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	32	11	4
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	34	2	12
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	34	5	0
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	34	7	105
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	34	9	8
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	34	11	20
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	30	2	12
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	30	5	0
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	30	7	48
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	30	9	7
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	30	11	0
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	31	2	3
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	31	5	0
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	31	7	27
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	31	9	2
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	31	11	0
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	32	2	1
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	32	5	0
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	32	7	9
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	32	9	1
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	32	11	0
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	34	2	10
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	34	5	0
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	34	7	41
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	34	9	6
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	34	11	0
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	30	2	270
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	30	5	1
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	30	7	1856
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	30	9	64
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	30	11	72
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	31	2	160
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	31	5	0
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	31	7	1584
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	31	9	21
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	31	11	57
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	32	2	35
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	32	5	0
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	32	7	334
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	32	9	7
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	32	11	13
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	34	2	232
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	34	5	0
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	34	7	1689
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	34	9	52
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	34	11	65
Vihdintie	Mannerheimintie	Kauppalantie	6	30	2	432
Vihdintie	Mannerheimintie	Kauppalantie	6	30	5	8

Vihdintie	Mannerheimintie	Kauppalantie	6	30	7	2507
Vihdintie	Mannerheimintie	Kauppalantie	6	30	9	171
Vihdintie	Mannerheimintie	Kauppalantie	6	30	11	149
Vihdintie	Mannerheimintie	Kauppalantie	6	31	2	256
Vihdintie	Mannerheimintie	Kauppalantie	6	31	5	6
Vihdintie	Mannerheimintie	Kauppalantie	6	31	7	2139
Vihdintie	Mannerheimintie	Kauppalantie	6	31	9	55
Vihdintie	Mannerheimintie	Kauppalantie	6	31	11	118
Vihdintie	Mannerheimintie	Kauppalantie	6	32	2	56
Vihdintie	Mannerheimintie	Kauppalantie	6	32	5	0
Vihdintie	Mannerheimintie	Kauppalantie	6	32	7	451
Vihdintie	Mannerheimintie	Kauppalantie	6	32	9	18
Vihdintie	Mannerheimintie	Kauppalantie	6	32	11	26
Vihdintie	Mannerheimintie	Kauppalantie	6	34	2	372
Vihdintie	Mannerheimintie	Kauppalantie	6	34	5	7
Vihdintie	Mannerheimintie	Kauppalantie	6	34	7	2281
Vihdintie	Mannerheimintie	Kauppalantie	6	34	9	138
Vihdintie	Mannerheimintie	Kauppalantie	6	34	11	134
Vihdintie	Kauppalantie	Korppaanmäentie	7	30	2	352
Vihdintie	Kauppalantie	Korppaanmäentie	7	30	5	5
Vihdintie	Kauppalantie	Korppaanmäentie	7	30	7	2042
Vihdintie	Kauppalantie	Korppaanmäentie	7	30	9	139
Vihdintie	Kauppalantie	Korppaanmäentie	7	30	11	121
Vihdintie	Kauppalantie	Korppaanmäentie	7	31	2	208
Vihdintie	Kauppalantie	Korppaanmäentie	7	31	5	5
Vihdintie	Kauppalantie	Korppaanmäentie	7	31	7	1742
Vihdintie	Kauppalantie	Korppaanmäentie	7	31	9	45
Vihdintie	Kauppalantie	Korppaanmäentie	7	31	11	96
Vihdintie	Kauppalantie	Korppaanmäentie	7	32	2	46
Vihdintie	Kauppalantie	Korppaanmäentie	7	32	5	0
Vihdintie	Kauppalantie	Korppaanmäentie	7	32	7	367
Vihdintie	Kauppalantie	Korppaanmäentie	7	32	9	14
Vihdintie	Kauppalantie	Korppaanmäentie	7	32	11	22
Vihdintie	Kauppalantie	Korppaanmäentie	7	34	2	303
Vihdintie	Kauppalantie	Korppaanmäentie	7	34	5	5
Vihdintie	Kauppalantie	Korppaanmäentie	7	34	7	1858
Vihdintie	Kauppalantie	Korppaanmäentie	7	34	9	113
Vihdintie	Kauppalantie	Korppaanmäentie	7	34	11	109
Vihdintie	Korppaanmäentie	Lapinmäentie	8	30	2	265
Vihdintie	Korppaanmäentie	Lapinmäentie	8	30	5	14
Vihdintie	Korppaanmäentie	Lapinmäentie	8	30	7	1985
Vihdintie	Korppaanmäentie	Lapinmäentie	8	30	9	118
Vihdintie	Korppaanmäentie	Lapinmäentie	8	30	11	115
Vihdintie	Korppaanmäentie	Lapinmäentie	8	31	2	157
Vihdintie	Korppaanmäentie	Lapinmäentie	8	31	5	12
Vihdintie	Korppaanmäentie	Lapinmäentie	8	31	7	1694
Vihdintie	Korppaanmäentie	Lapinmäentie	8	31	9	38
Vihdintie	Korppaanmäentie	Lapinmäentie	8	31	11	90
Vihdintie	Korppaanmäentie	Lapinmäentie	8	32	2	34
Vihdintie	Korppaanmäentie	Lapinmäentie	8	32	5	1
Vihdintie	Korppaanmäentie	Lapinmäentie	8	32	7	357
Vihdintie	Korppaanmäentie	Lapinmäentie	8	32	9	12
Vihdintie	Korppaanmäentie	Lapinmäentie	8	32	11	20

Vihdintie	Korppaanmäentie	Lapinmäentie	8	34	2	229
Vihdintie	Korppaanmäentie	Lapinmäentie	8	34	5	13
Vihdintie	Korppaanmäentie	Lapinmäentie	8	34	7	1806
Vihdintie	Korppaanmäentie	Lapinmäentie	8	34	9	96
Vihdintie	Korppaanmäentie	Lapinmäentie	8	34	11	103
Lapinmäentie	Vihdintie	Huopalahdentie	9	30	2	102
Lapinmäentie	Vihdintie	Huopalahdentie	9	30	5	5
Lapinmäentie	Vihdintie	Huopalahdentie	9	30	7	861
Lapinmäentie	Vihdintie	Huopalahdentie	9	30	9	50
Lapinmäentie	Vihdintie	Huopalahdentie	9	30	11	22
Lapinmäentie	Vihdintie	Huopalahdentie	9	31	2	61
Lapinmäentie	Vihdintie	Huopalahdentie	9	31	5	4
Lapinmäentie	Vihdintie	Huopalahdentie	9	31	7	735
Lapinmäentie	Vihdintie	Huopalahdentie	9	31	9	16
Lapinmäentie	Vihdintie	Huopalahdentie	9	31	11	17
Lapinmäentie	Vihdintie	Huopalahdentie	9	32	2	13
Lapinmäentie	Vihdintie	Huopalahdentie	9	32	5	0
Lapinmäentie	Vihdintie	Huopalahdentie	9	32	7	155
Lapinmäentie	Vihdintie	Huopalahdentie	9	32	9	5
Lapinmäentie	Vihdintie	Huopalahdentie	9	32	11	4
Lapinmäentie	Vihdintie	Huopalahdentie	9	34	2	88
Lapinmäentie	Vihdintie	Huopalahdentie	9	34	5	4
Lapinmäentie	Vihdintie	Huopalahdentie	9	34	7	784
Lapinmäentie	Vihdintie	Huopalahdentie	9	34	9	40
Lapinmäentie	Vihdintie	Huopalahdentie	9	34	11	20
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	30	2	246
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	30	5	6
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	30	7	1767
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	30	9	75
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	30	11	32
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	31	2	146
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	31	5	5
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	31	7	1508
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	31	9	24
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	31	11	25
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	32	2	32
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	32	5	0
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	32	7	318
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	32	9	8
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	32	11	6
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	34	2	212
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	34	5	5
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	34	7	1608
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	34	9	61
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	34	11	29
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	30	2	172
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	30	5	3
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	30	7	1634
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	30	9	70
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	30	11	30
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	31	2	102
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	31	5	3
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	31	7	1395

Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	31	9	22
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	31	11	23
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	32	2	22
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	32	5	0
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	32	7	294
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	32	9	7
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	32	11	5
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	34	2	148
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	34	5	3
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	34	7	1487
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	34	9	56
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	34	11	27
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	30	2	80
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	30	5	4
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	30	7	921
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	30	9	33
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	30	11	22
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	31	2	45
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	31	5	3
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	31	7	645
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	31	9	11
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	31	11	13
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	32	2	17
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	32	5	0
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	32	7	104
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	32	9	5
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	32	11	3
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	34	2	68
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	34	5	4
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	34	7	812
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	34	9	26
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	34	11	19
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	30	2	77
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	30	5	4
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	30	7	1006
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	30	9	28
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	30	11	23
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	31	2	43
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	31	5	3
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	31	7	704
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	31	9	9
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	31	11	14
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	32	2	16
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	32	5	0
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	32	7	113
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	32	9	4
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	32	11	3
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	34	2	66
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	34	5	4
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	34	7	887
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	34	9	23
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	34	11	20
Turku motorway	End of middle lane	Helsinki - Espoo border	14	30	2	157

Turku motorway	End of middle lane	Helsinki - Espoo border	14	30	5	8
Turku motorway	End of middle lane	Helsinki - Espoo border	14	30	7	1927
Turku motorway	End of middle lane	Helsinki - Espoo border	14	30	9	61
Turku motorway	End of middle lane	Helsinki - Espoo border	14	30	11	45
Turku motorway	End of middle lane	Helsinki - Espoo border	14	31	2	88
Turku motorway	End of middle lane	Helsinki - Espoo border	14	31	5	7
Turku motorway	End of middle lane	Helsinki - Espoo border	14	31	7	1349
Turku motorway	End of middle lane	Helsinki - Espoo border	14	31	9	20
Turku motorway	End of middle lane	Helsinki - Espoo border	14	31	11	27
Turku motorway	End of middle lane	Helsinki - Espoo border	14	32	2	33
Turku motorway	End of middle lane	Helsinki - Espoo border	14	32	5	0
Turku motorway	End of middle lane	Helsinki - Espoo border	14	32	7	217
Turku motorway	End of middle lane	Helsinki - Espoo border	14	32	9	9
Turku motorway	End of middle lane	Helsinki - Espoo border	14	32	11	6
Turku motorway	End of middle lane	Helsinki - Espoo border	14	34	2	134
Turku motorway	End of middle lane	Helsinki - Espoo border	14	34	5	8
Turku motorway	End of middle lane	Helsinki - Espoo border	14	34	7	1698
Turku motorway	End of middle lane	Helsinki - Espoo border	14	34	9	49
Turku motorway	End of middle lane	Helsinki - Espoo border	14	34	11	39

Table 3: Speed on road segments by vehicle categories

Street name	Beginning of segment	End of segment	road_id	fzk	speed [km/h]
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	2	43
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	5	43
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	7	43
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	9	43
Metsäläntie	Postintaival	Hämeenlinnanväylä east ramps	1	11	43
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	2	43
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	5	43
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	7	43
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	9	43
Metsäläntie	Hämeenlinnanväylä east ramps	Hämeenlinnanväylä west ramps	2	11	43
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	2	43
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	5	43
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	7	43
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	9	43
Hämeenlinnanväylä ramp (SW)	Metsäläntie	Hämeenlinnanväylä, south	3	11	43
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	2	43
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	5	43
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	7	43
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	9	43
Hämeenlinnanväylä ramp (SE)	Hämeenlinnanväylä, from south	Metsäläntie	4	11	43
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	2	57
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	5	57
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	7	57
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	9	57
Hämeenlinnanväylä	Ramp from Metsäläntie	Hakamäentie	5	11	60
Vihdintie	Mannerheimintie	Kauppalantie	6	2	30
Vihdintie	Mannerheimintie	Kauppalantie	6	5	30
Vihdintie	Mannerheimintie	Kauppalantie	6	7	30
Vihdintie	Mannerheimintie	Kauppalantie	6	9	30
Vihdintie	Mannerheimintie	Kauppalantie	6	11	33
Vihdintie	Kauppalantie	Korppaanmäentie	7	2	30
Vihdintie	Kauppalantie	Korppaanmäentie	7	5	30
Vihdintie	Kauppalantie	Korppaanmäentie	7	7	30
Vihdintie	Kauppalantie	Korppaanmäentie	7	9	30
Vihdintie	Kauppalantie	Korppaanmäentie	7	11	33
Vihdintie	Korppaanmäentie	Lapinmäentie	8	2	30
Vihdintie	Korppaanmäentie	Lapinmäentie	8	5	30
Vihdintie	Korppaanmäentie	Lapinmäentie	8	7	30
Vihdintie	Korppaanmäentie	Lapinmäentie	8	9	30
Vihdintie	Korppaanmäentie	Lapinmäentie	8	11	33
Lapinmäentie	Vihdintie	Huopalahdentie	9	2	25
Lapinmäentie	Vihdintie	Huopalahdentie	9	5	25
Lapinmäentie	Vihdintie	Huopalahdentie	9	7	25
Lapinmäentie	Vihdintie	Huopalahdentie	9	9	25
Lapinmäentie	Vihdintie	Huopalahdentie	9	11	25
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	2	23
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	5	23
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	7	23
Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	9	23

Huopalahdentie	Lapinmäentie	Ulvilantie (south loop)	10	11	23
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	2	23
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	5	23
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	7	23
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	9	23
Huopalahdentie	Ulvilantie (south loop)	Turku motorway	11	11	23
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	2	62
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	5	62
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	7	62
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	9	62
Turku motorway (north ramp)	Huopalahdentie	End of middle lane	12	11	62
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	2	62
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	5	62
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	7	62
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	9	62
Turku motorway (south ramp)	Beginning of middle lane	Huopalahdentie	13	11	65
Turku motorway	End of middle lane	Helsinki - Espoo border	14	2	72
Turku motorway	End of middle lane	Helsinki - Espoo border	14	5	72
Turku motorway	End of middle lane	Helsinki - Espoo border	14	7	72
Turku motorway	End of middle lane	Helsinki - Espoo border	14	9	72
Turku motorway	End of middle lane	Helsinki - Espoo border	14	11	75

Table 4. Noise receptor data (average size of a household: 2,5 people).

Street name	from	to	Road id	Receptor id	m to start	m to end	side	h_dist	opposite	floors with apartments	lowest receptor	windows
Vt3	Metsäläntie	Ryytimaantie	5	1	114	146	R	71	0	2	6	20
Vt3	Metsäläntie	Ryytimaantie	5	2	146	187	R	65	0	2	6	24
Vt3	Metsäläntie	Ryytimaantie	5	3	187	203	R	59	0	1	5	6
Vt3	Metsäläntie	Ryytimaantie	5	4	203	249	R	67	0	2	7	52
Vt3	Metsäläntie	Ryytimaantie	5	5	298	302	R	59	0	3	7	12
Vt3	Metsäläntie	Ryytimaantie	5	6	312	321	R	30	0	1	8	18
Vt3	Metsäläntie	Ryytimaantie	5	7	343	376	R	28	0	3	15	12
Vt3	Metsäläntie	Ryytimaantie	5	8	384	391	R	36	0	4	16	20
Vt3	Ryytimaantie	Matkamiehenpolku	5	9	62	85	R	44	29	4	3	52
Vt3	Ryytimaantie	Matkamiehenpolku	5	10	76	82	L	29	44	2	4	6
Vt3	Ryytimaantie	Matkamiehenpolku	5	11	118	155	R	40	46	3	3	12
Vt3	Ryytimaantie	Matkamiehenpolku	5	12	109	113	L	46	40	1	2	0
Vt3	Ryytimaantie	Matkamiehenpolku	5	13	122	127	L	50	40	4	8	8
Vt3	Ryytimaantie	Matkamiehenpolku	5	14	162	199	R	32	0	4	2	16
Vt3	Ryytimaantie	Matkamiehenpolku	5	15	205	246	R	27	45	3	4	24
Vt3	Ryytimaantie	Matkamiehenpolku	5	16	196	204	L	45	27	4	8	4
Vt3	Matkamiehenpolku	Kylännevantie	5	17	1	17	R	31	0	3	3	3
Vt3	Matkamiehenpolku	Kylännevantie	5	18	62	76	R	48	0	3	4	6
Vt3	Matkamiehenpolku	Kylännevantie	5	19	88	130	R	65	0	3	10	18
Vihdintie	Ahjokuja	Talontie	7	20	51	81	R	43	0	2	4	12
Vihdintie	Ahjokuja	Talontie	6	21	81	98	R	46	0	3	4	7
Vihdintie	Talontie	Isonnevantie	8	22	0	19	R	34	32	3	4.5	6
Vihdintie	Talontie	Isonnevantie	9	23	2	26	L	32	34	3	1.5	33
Lapinmäentie	Vihdintie	Korppaantie	9	24	40	56	L	12	0	3	4	6
Lapinmäentie	Korppaantie	Ruusutarhantie	9	25	0	17	R	13	0	3	4	3
Lapinmäentie	Korppaantie	Ruusutarhantie	9	26	15	32	L	23	0	2	4	36
Lapinmäentie	Korppaantie	Ruusutarhantie	9	27	41	58	R	15	0	3	4	12
Lapinmäentie	Korppaantie	Ruusutarhantie	9	28	46	79	L	27	0	2	4	36
Lapinmäentie	Ruusutarhantie	Ansaritie	9	29	0	12	R	14	29	3	3	12
Lapinmäentie	Ruusutarhantie	Ansaritie	9	30	6	36	L	29	14	3	4	33
Lapinmäentie	Ansaritie	Niemenmäentie	9	31	7	22	R	15	29	3	3	0
Lapinmäentie	Niemenmäentie	Huopalahdentie	9	32	60	86	R	30	0	10	6	180
Huopalahdentie	Lapinmäentie	Ulvilantie	10	33	56	111	R	7	0	2	2	78
Huopalahdentie	Ulvilantie	Vt1	11	34	53	67	L	55	0	7	12	42

Huopalahdentie	Ulvilantie	Vt1	11	35	119	132	L	49	0	7	11	28
Huopalahdentie	Ulvilantie	Vt1	11	36	189	202	L	51	0	7	10	80
Vt1	Huopalahdentie	Professorintie	12	37	112	185	R	97	0	4	0	40
Vt1	Huopalahdentie	Professorintie	12	38	249	301	R	95	0	3	2	18
Vt1	Huopalahdentie	Professorintie	12	39	301	315	R	50	0	3	2	6
Vt1	Huopalahdentie	Professorintie	12	40	371	386	R	106	0	5	4.5	5
Vt1	Huopalahdentie	Professorintie	12	41	434	476	R	98	0	6	3	36