5.11 Noise

This chapter describes vehicle noise costs, including general information on how noise is quantified, the noise emissions of various types of vehicles, and estimates of noise cost values.

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5.11.2 Definition

Noise refers to unwanted sounds and vibrations. Motor vehicles cause various types of noise, includes engine acceleration, tire/road contact, braking, horns and vehicle theft alarms. Heavy vehicles can cause vibration and infrasound (low frequency noise). According to an OECD report, "*Transport is by far the major source of noise, ahead of building or industry, with road traffic the chief offender*."[1] Motorcycles, trucks and buses are major contributors to traffic noise.[2] At low speeds most noise comes from vehicle engine and drivetrain, at higher speeds aerodynamic and tire/road noise dominate.[3]

[1] OECD (1990), *Environmental Policies for Cities in the 1990s*, OECD (www.oecd.org), cited in Poldy, p.29.
[2] MacKenzie, Dower & Chen (1992), *The Going Rate*, World Resources Institute (www.wri.org), p. 21.
[3] Homberger, Kell and Perkins (1992), *Fundamentals of Traffic Engineering, 13th Edition*, Institute of Transportation Studies, UCB (www.its.berkeley.edu), p.31-3.

5.11.3 Discussion

Several factors affect the amount of noise emitted by traffic, and its costs:

- *Vehicle type*. Motorcycles, heavy vehicles (trucks and buses), and vehicles with faulty exhaust systems tend to produce high noise levels.
- *Engine type*. Older diesel engines tend to be the noisiest, followed by gasoline and natural gas, hybrid, and electric vehicles being quietest.
- *Traffic speed, stops and inclines*. Lower speeds tend to produce less engine, wind and road noise. Engine noise is greatest when a vehicle is accelerating or climbing an incline. Aggressive driving, with faster acceleration and harder stopping, increases noise.
- *Pavement type and condition*. Certain pavement types and smoother road surfaces emit less noise.[4] "Quiet pavement" research indicates that *open-graded friction course* (OGFC) and *porous friction courses* (PFC) asphalts, and *whisper grinding* and *longitudinal tining* produce less traffic noise.[5]
- *Distance and barriers.* Noise declines with distance and is reduced by structures, walls, trees, hills and sound-resistant design features such as double-paned windows.

Noise is measured using hedonic price surveys, as discussed in Chapter 4.[6] This involves the effects of noise on residential property values. Several studies show residential property values typically decline about 0.5% for each unit change in Leq.[7] These results are used to develop general property value depreciation indexes.[8] The OECD recommends a noise depreciation index of 0.5% of property value per decibel increase if noise levels are above 50 dB(A) Leq (24 hours).[9] Lee estimates traffic noise costs at $21 annually per housing unit per decibel increase.[10]

Such studies are criticized on several grounds. Their noise level thresholds tend to be arbitrary, the data used are often incomplete, they assume that home buyers have accurate knowledge of noise exposure at each location, and they do not account for non-residential noise impacts (such as on businesses and pedestrians). Most U.S. noise cost models measure the marginal cost of an additional highway vehicle, and so are inappropriate for evaluating surface street traffic noise costs. Verhoef concludes that such estimates of

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[4] Bill Wilson (2005), "New Noise Solution Research Shows Promise And An Enthusiastic Effort," *Roads & Bridges*, Vol. 43 No. 2 (www.roadsbridges.com), February 2005.

[5] FHWA (2005), *Quiet Pavement Pilot Program.* FHWA (www.fhwa.dot.gov); at www.fhwa.dot.gov/environment/noise/qpppeml.htm

[6] EC (2005), *ExternE: Externalities of Energy - Methodology 2005 Update*, Directorate-General for Research Sustainable Energy Systems, European Commission (www.externe.info).

[7] From Pearce and Markandya (1989), *Environmental Policy Benefits: Monetary Valuation*, OECD (www.oecd.org).

[8] Based on Weatherall 1988; Quinet 1990; and Steeting 1990 as cited in BTCE & EPA (1994), "The Costing and Costs of Transport Externalities: A Review," *Victorian Transport Externalities Study*, Vol. 1, Environment Protection Authority (www.epa.vic.gov.au).

[9] M. Modra (1984), *Cost-Benefit Analysis of the Application of Traffic Noise Insulation Measures to Existing Houses*, EPA (www.epa.vic.gov.au), 1984, cited in Poldy, 1993.

[10] Douglass Lee, "Efficient Highway User Charges," USDOT, as cited in MacKenzie, Dower & Chen (1992), *The Going Rate*, World Resources Institute (www.wri.org).

traffic noise represent only 1/8th of the total cost[11] and Bein interprets Sælensminde's research to imply that hedonic noise surveys identify only about 1/6th of total motor vehicle noise costs.[12]

Measuring Noise[13]
Noise is measured in *decibels* (dB), a logarithmic scale. A 10 dB increase represents a doubling in noise level. *Decibels A-weighted*, (indicated "dB(A)") units emphasize the frequency sensitivities of human hearing, and correlate well with subjective impressions of loudness. Common noise levels range from 30 to 90 dB(A). Decibels are an instantaneous measurement, so various indexes are used to measure noise over a period of time:

- *Leq* represents the equivalent continuous sound level in dB(A) for a specific time period. Leq (8 hours) is used in many traffic noise standards established by OECD and WHO.
- L_{10} represents the dB(A) level that is exceeded 10% of a time period (often one hour). Analogous measurements, L_{01} L_{05}, L_{50}, refer to noise levels exceeded 1%, 5% and 50% of the time period. L_{10}*(18 hours)* is the mean of the hourly values taken over an 18-hour period, typically from 6 a.m. to midnight. L_{10} is often used to define traffic noise.
- *MNL (Maximum Noise Level)* is the loudest noise during a certain period. Some researches consider this index to correlate with noise annoyance better than Leq and L_{10}, but does not address the number of noise events, and is not widely used.

Decibels Examples

130 - Threshold of pain

120 - Loud car horn close by

110 - Busy airport

100 - Inside underground train

90 - Inside diesel bus

80 - Busy residential road

70 - Conversational speech

60 - Background music

50 - Quiet office

40 - Quiet bedroom

20 - Silent room

10 - Threshold of hearing

One study found that traffic volume increases of a few hundred motor vehicles per day reduced adjacent residential property values by 5-25%.[14] Assuming 150 residences per mile of urban residential street, with average values of $100,000 per residence, this represents an annualized cost of approximately $1 million (5% discount rate over 25 years). Assuming 500 additional vehicles per day cause average property values to decline by 10%, and that noise represents one-third of this cost (reduced safety and privacy are other possible costs), such traffic noise costs average 18¢ per vehicle mile.[15]

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[11] Erik Verhoef (1994), "External Effects and Social Costs of Road Transport," *Trans. Res.*, Vo.28A, p. 286.
[12] Peter Bein (1994), *Barnet Hastings Benefit Cost Analysis*, BC Ministry of Transportation (www.th.gov.bc.ca).
[13] BTCE & EPA (1994), "The Costing and Costs of Transport Externalities: A Review," *Victorian Transport Externalities Study*, Vol. 1, Environment Protection Authority - Victoria, Australia (www.epa.vic.gov.au).
[14] Gordon Bagby (1980), "Effects of Traffic Flow on Residential Property Values," *Journal of the American Planning Association*,(www.planning.org/japa) Vol. 46, No. 1, January, pp. 88-94. Also see William Hughes and C.F. Sirmans (1992), "Traffic Externalities and Single-Family House Prices," *Journal of Regional Science* (www.blackwellpublishing.com), Vol. 32, No. 4, 1992, pp. 487-500.
[15] $2.8 million x 10% ÷ 3 ÷ 365 days per year ÷ 500 vehicles per day.

The number of residences impacted by traffic noise is significant in most developed countries. A.L. Brown and K.C. Lam estimate that approximately 25% of Australian urban dwellings are located on roads with over 2,000 vehicles per day and higher traffic speeds. Over 12% of dwellings in Australia directly front roadways carrying 8,000 or more vehicles per day. In addition, 8% of houses on low volume (<1,000 vehicles per day) are located close enough to a high traffic road to experience traffic noise exceeding 68 dB. Thus, approximately 1/3 of houses experience significant traffic noise.[16]

Table 5.11.3-1 shows estimates of total national transportation noise costs as a percentage of GDP. Some research indicates that property value depreciation due to noise is non-linear, and increases from 0.5% per dB(A) unit increase in the range of 50 to 60 dB(A), rising to 0.8% per unit increase above 65 dB(A).[17]

Table 5.11.3-1 **Selected Estimates of Total Transport Noise Costs**[18]

Country	Percent of GDP
France	0.24
Germany	0.20
Norway	0.23
United Kingdom	0.50
United States,	0.06 - 0.21
Japan	0.20
OECD, Average	0.15

16 A. L. Brown and K.C. Lam (1994), “Can I Play on the Road, Mum? - Traffic and Homes in Urban Australia,” *Road and Transport Research* (www.arrb.com.au), Vol. 3, No. 1, March 1994, p. 12-23.
17 BTCE & EPA (1994), “The Costing and Costs of Transport Externalities: A Review,” *Victorian Transport Externalities Study*, EPA (www.epa.vic.gov.au), Table 3.4, based on Weatherall, 1988.
18 BTCE & EPA (1994), based on Bouladon 1991 and Quinet 1990.

5.11.4 Estimates

All values are in U.S. dollars unless otherwise indicated.

Summary Table

Table 5.11.4-1 **Noise Studies Summary Table – Selected Urban Values**

Publication	Costs		Cost Value	2007 USD / VMT
FHWA (1997)	Automobile		median values 0.11	0.001
Urban highways	Pickup & Van		0.10	0.001
	Buses		1.72	0.022
1997 cents per	Combination Trucks		3.73	0.048
Vehicle-mile	All Vehicles		0.24	0.003
CE Delft (2008)	Car	Day	0.76	0.014
Urban roads		Night	1.39	0.025
	Motorcycle	Day	1.53	0.027
2000 Euro cents		Night	2.78	0.050
per veh km.	Bus	Day	3.81	0.068
		Night	6.95	0.124
	Heavy truck	Day	7.01	0.125
		Night	12.78	0.228
Delucchi and Hsu	Cars (Urban Arterial)		1.18	0.002
(1998)	Medium trucks		7.02	0.011
	Heavy trucks		20.07	0.031
1991 USD/1000 VMT	Buses		7.18	0.011
	Motorcycle		8.71	0.013
GVRD (1993)	Vehicles		1993* Can. cents/km. 0.5	0.009

*More detailed descriptions of these studies are found below, along with summaries of other studies. 2007 Values have been adjusted for inflation by Consumer Price Index. * Indicates that currency date is assumed to be the same as study date.*

Distance-based Estimates

- Apogee Research estimated noise costs in Boston, MA and Portland, ME for several modes at high, medium and low densities. Totals are shown in Table 5.11.4-2.

Table 5.11.4-2 **Noise Costs in Two Cities** (Cents Per Passenger Mile)[19]

	Automobile		Comm. Rail		Rail Transit		Bus	
Boston	Expwy	Non-Expwy	Peak	Off-P	Peak	Off-P	Peak	Off-P
High	0.3	0.6	0.4	1.1	n/a	n/a	0.5	1.3
Medium	0.1	0.2	0.1	0.3	0.3	0.4	0.2	0.5
Low	<0.1	<0.1	0.1	0.1	n/a	n/a	<1.0	0.1
Portland								
High	0.2	0.5	n/a	n/a	n/a	n/a	1.1	1.0
Medium	0.1	0.1	n/a	n/a	n/a	n/a	0.2	0.2
Low	<0.1	<0.1	n/a	n/a	n/a	n/a	0.1	0.1

- CE Delft (2008) provides a matrix of European cost estimates divided into day and night values, as well as into urban, suburban and rural categories, summarized in Table 511.4-3. The original source includes ranges of values.

Table 5.11.4-3 **Central Road and Rail Traffic Noise Marginal Costs** (€ct/vkm)[20]

Mode	Time	Urban	Suburban	Rural
Car	Day	0.76	0.12	0.01
	Night	1.39	0.22	0.03
Motorcycle	Day	1.53	0.24	0.03
	Night	2.78	0.44	0.05
Bus	Day	3.81	0.59	0.07
	Night	6.95	1.10	0.13
LGV	Day	3.81	0.59	0.07
	Night	6.95	1.10	0.13
HGV	Day	7.01	1.10	0.13
	Night	12.78	2.00	0.23
Passenger Train	Day	23.65	20.61	2.57
	Night	77.99	34.40	4.29
Freight Train	Day	41.93	40.06	5.00

- Delucchi and Shi-Ling Hsu calculate marginal noise costs per 1,000 miles traveled for five vehicle classes on six urban roadway types, as indicated in the table below. Their model takes into account the impacts of traffic noise above a threshold on residential property values, scaled up 27% to include non-residential exposures.[21]

[19] Apogee Research (1994), *The Costs of Transportation*, Conservation Law Foundation (www.clf.org), p. 161.
[20] M. Maibach, et al. (2008), *Handbook on Estimation of External Cost in the Transport Sector,* CE Delft (www.ce.nl) Table 22 p 69; at http://ec.europa.eu/transport/costs/handbook/doc/2008_01_15_handbook_external_cost_en.pdf
[21] Their conclusion that vehicles produce minimal noise costs on collectors and no noise costs on local roads is contradicted by other studies which indicate that residential property values along low volume roads are quite

Table 5.11.4-4 **Marginal Noise Costs in Urban Areas** (1991$/1000 VMT)[22]

	Interstate	Other Freeways	Principle Arterials	Minor Arterials	Collectors	Local Roads
Light Automobiles	2.96	4.25	1.18	0.57	0.07	0.00
Medium Trucks	8.50	13.20	7.02	5.37	1.05	0.00
Heavy Trucks	16.69	30.80	20.07	29.93	4.93	0.00
Buses	6.36	9.77	7.18	6.42	1.22	0.00
Motorcycles	17.15	27.03	8.71	4.67	0.56	0.00

- Table 5.11.4-5 summarizes marginal highway noise costs for various vehicles estimated by the US Federal Highway Administration. This reflects the marginal cost of an additional vehicle on major highways, and does not reflect noise exposure on surface streets, where the vehicle noise impact costs are likely to be higher.

Table 5.11.4-5 **Estimated Highway Noise Costs** (1997 Cents Per Vehicle Mile)[23]

	Rural Highways			Urban Highways			All Highways		
	High	Med.	Low	High	Med.	Low	High	Med.	Low
Automobile	0.03	0.01	0.00	0.30	0.11	0.03	0.20	0.06	0.02
Pickup & Van	0.03	0.01	0.00	0.27	0.10	0.03	0.17	0.06	0.02
Buses	0.35	0.13	0.04	4.55	1.72	0.48	2.79	1.06	0.30
Single Unit Trucks	0.27	0.10	0.03	3.14	1.19	0.33	1.85	0.70	0.20
Combination Trucks	0.68	0.26	0.07	9.86	3.73	1.05	4.24	1.61	0.45
All Vehicles	0.08	0.03	0.01	0.64	0.24	0.07	0.42	0.16	0.05

- Forkenbrock estimates noise pollution costs for large intercity trucks to average 0.04¢ per ton-mile of freight shipped.[24]

- Table 5.11.4-6 shows estimated residential noise damage costs for travel on high-volume highways. Separate cost estimates are also provided for various weight trucks. They state that "*As traffic volume on a particular road increases, the [marginal] noise damage contribution of a single vehicle decreases*" which implies higher marginal costs for vehicle travel on low volume, local roads and streets.

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sensitive to changes in traffic volume, such as Gordon Bagby (1980), "Effects of Traffic Flow on Residential Property Values," *Journal of the American Planning Association* (www.planning.org/japa), Vol. 46, No. 1, pp. 88-94). This suggests that their "Base-Case" estimates are probably low.

[22] Mark Delucchi and Shi-Ling Hsu (1998), "External Damage Cost of Noise Emitted from Motor Vehicles," *Journal of Transportation and Statistics* (www.bts.gov/publications/jts/),Vol. 1, No. 3, pp. 1-24. Also see Mark Delucchi (2000), "Environmental Externalities of Motor-Vehicle Use in the US," *Journal of Transportation Economics and Policy*, (www.bath.ac.uk/e-journals/jtep),Vol. 34, No., pp. 135-168.

[23] FHWA (1997) *1997 Federal Highway Cost Allocation Study*, USDOT (www.dot.gov), Table V-22; at www.fhwa.dot.gov/policy/hcas/summary/index.htm.

[24] David Forkenbrock 1999, "External Costs of Intercity Truck Freight Transportation," *Transportation Research A* (www.elsevier.com/locate/tra), Vol. 33, No. 7/8, Sept./Nov. 1999, pp. 505-526.

Table 5.11.4-6 **Costs Per Noise Passenger Car Equivalent** (1993 Cents Per Mile)[25]

Miles Per Hour:	20	25	30	35	40	45	50	55	60
Urban, CBD	0.02	0.03	0.05	0.07	0.10	0.13	0.16	0.20	0.24
Urban Fringe	0.02	0.03	0.08	0.13	0.19	0.25	0.32	0.40	0.51
Urban, Outer CBD	0.00	0.01	0.02	0.03	0.05	0.06	0.08	0.10	0.12
Urban, Residential	0.02	0.03	0.05	0.07	0.10	0.13	0.16	0.19	0.23
Urban, Rural Character	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
Rural, Sparse Development	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rural, Dense Development	0.02	0.03	0.06	0.08	0.12	0.16	0.20	0.24	0.28

This table indicates estimated residential noise costs for motor vehicle travel on 110,000 average annual daily traffic highways.

- Per Kågeson estimates motor vehicle noise costs in Europe at 0.6¢ per passenger mile (3.0 ECU/1,000 km).[26]

- Theodore Keeler et al. estimated the marginal noise cost of an added freeway vehicle mile at 0.1-0.2¢ in 1975 (0.2-0.4¢ in current dollars), but offer no estimate for impacts on local streets, which they state would be considerably higher.[27]

- David Maddison, et al, develop an estimate of noise costs for the U.K. as summarized in Table 5.11.4-7. They assume that heavy trucks produce 3 times, and buses and motorcycles twice, the noise costs of an average automobile.[28]

Table 5.11.4-7 **Noise Costs Per Kilometer**

	Pence Per Passenger Km	1996 US$ Per Passenger Mile
Car	0.41	$0.018
Bus	0.097	$0.004
Motorcycle	1.18	$0.035
Heavy Goods Vehicle	1.96	$0.053

- Peter Miller and John Moffet estimate noise costs at 0.14¢ to 0.23¢ per automobile mile and three times higher for buses.[29]

- Quinet summarizes noise cost estimates by various European researchers, indicating an average estimate of approximately 0.7¢ per vehicle mile (U.S. dollars).[30]

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[25] Daniel Haling and Harry Cohen (1997), "Residential Noise Damage Costs Caused by Motor Vehicles," *Transportation Research Record 1559*, (www.trb.org), 1997, pp. 84-93.
[26] Per Kågeson (1993), *Getting the Prices Right*, European Fed. for Transport & Env. (www.transportenvironment.org), p 102.
[27] IURD (1975), *The Full Cost of Urban Transportation*, Monograph 21, Institute of Urban and Regional Development (http://iurd.berkeley.edu), p. 52.
[28] David Maddison, et al (1996), *The True Costs of Road Transport*, Earthscan (www.earthscan.co.uk), p. 95.
[29] NRDC (1993), *The Price of Mobility*, National Resources Defense Council (www.nrdc.org), Oct. 1993, p.35.
[30] Emile Quinet (1997), "Full Social Cost of Transportation in Europe," *The Full Costs and Benefits of Transportation*, Springer (www.springer.com), pp. 69-111, Table A1.

- In an example assuming $1,000 per linear meter of highway noise barrier L.R. Rilett calculates that mitigation costs average about 3¢ per peak period vehicle kilometer, or about 1¢ for automobiles, 14¢ for medium trucks, and 43¢ for heavy trucks.[31]

- Sælensminde uses previous studies to estimate noise costs for Norway, resulting in a range from $88 to $541 per capita annually, or about 1¢ to 5.4¢ per VMT.[32]

- Transport 2021 estimates noise costs in the Greater Vancouver area equals 0.5¢ Canadian per km, or about 0.6¢ U.S. per mile.[33]

Other Estimates and Studies

- Bagby compared property values in two similar residential neighborhoods, one of which had unrestricted traffic flow, while the other had various traffic management strategies that significantly reduced traffic volumes. The results show that residential property values are highly sensitive to traffic on adjacent streets. Reducing traffic volumes by a few hundred motor vehicles per day increased adjacent residential property values by 5-25%.[34] Other studies found similar results.[35]

- An comprehensive study by Bateman, et al, indicates that that each decibel increase in traffic noise decreases residential property price in Scotland by 0.20%, with a standard error indicating that there is a 95% chance that the coefficient is greater than -0.04% and less than -0.37%.[36] The study also indicates that aircraft noise has a similar effect, and that views of roads also reduces residential property values.

- Research by the B.C. Ministry of Transportation and Highways indicates that noise costs average $1,000-1,500 (Canadian dollars) or more per affected person per year (residents of homes near busy streets and highways).[37]

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[31] L.R. Rilett (1995), "Allocating Pollution Costs Using Noise Equivalency Factors," *Transportation Research Record 1498*, TRB (www.trb.org), pp. 102-107.
[32] Kjartan Sælensminde (1992), *Environmental Costs Caused by Road Traffic In Urban Areas - Results From Previous Studies*, Institute for Transport Economics (www.toi.no).
[33] GVRD (1993), *Cost of Transporting People in the BC Lower Mainland*, GVRD (www.metrovancouver.org).
[34] Gordon Bagby (1980), "Effects of Traffic Flow on Residential Property Values," *Journal of the American Planning Association*, Vol. 46, No. 1, APA (www.planning.org), January 1980, pp. 88-94.
[35] William Hughes and C.F. Sirmans (1992), "Traffic Externalities and Single-Family House Prices," *Journal of Regional Science*, Vol. 32, No. 4, (www.blackwellpublishing.com/), pp. 487-500.
[36] Ian Bateman, Brett Day, Iain Lake and Andrew Lovett (2001), *The Effect of Road Traffic on Residential Property Values: A Literature Review and Hedonic Pricing Study*, Scottish Executive Development Department (www.scotland.gov.uk); at www.scotland.gov.uk/library3/housing/ertpv.pdf
[37] Dr. Peter Bein (1997), *Monetization of Environmental Impacts of Roads*, Planning Services Branch, B.C. Ministry of Transportation and Highways (www.gov.bc.ca/tran).

- Hokanson developed the relative noise factors shown in Table 5.11.4-8

Table 5.11.4-8 **Automobile Noise Equivalents by Speed**[38]

MPH:	20	25	30	35	40	45	50	55	60
Automobile	1	1	1	1	1	1	1	1	1
Medium Truck	18	16	15	14	13	13	12	12	11
Heavy Truck	113	83	66	54	45	38	32	30	26

- The Dutch Ministry of Environment publishes extensive research on transportation noise impacts, including formula and software for calculating impacts in specific conditions.[39] Their findings indicate that residents are more annoyed by aircraft and highway traffic than the same noise level produced by local traffic and railroads.[40]

- A Federal Transit Administration study indicates that as "Day-Night" sound level increases from 50 to 90 Ldn, the portion of residents who are highly annoyed by noise increases from approximately 0 to 100%.[41] This study indicates that at 50 feet, a 2-car LRT (Light Rail Transit) traveling at 25 mph produces about 52 dBA, a 4-car LRT at 25 mph produces about 60 dBA, and a RRT (Rapid Rail Transit) at 50 mph produces about 66 dBA (the equivalent noise of a heavy arterial traffic at 40 mph).

- Based on an review of available research, Gillen estimates that aviation noise reduces housing prices by 0.9% for each Noise Explores Factor (NEF) decibel increase.[42]

- A study of car alarm noise in New York City found that 91% of surveyed respondents said that car alarms reduced their quality of life, 76% said car alarms wake them at night, only 5% have responded to the sound of an alarm by calling the police about a possible theft, while 60% have called police to complain about car alarm noise.[43] It also found that car alarms are not very effective at preventing thefts: 95-99% of all alarms are false and cars with alarms are just as likely to be broken into those without.

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[38] Barry Hokanson and Martin Minkoff (1981), *Measures of Noise Damage Costs Attributable to Motor Vehicle Travel - Technical Report #135*, Urban and Regional Research, University of Iowa (www.uiowa.edu).
[39] VROM (1995), *Calculation of Road Traffic Noise*, Directorate for Noise and Traffic (www.vrom.nl); at www.xs4all.nl/~rigolett/ENGELS/index.html
[40] VROM (1993), *Response Functions for Environmental Noise in Residential Areas*, Ministry of Environment (www.vrom.nl).
[41] Harris Miller & Hanson, Inc. (1995), *Transit Noise and Vibration Impact Assessment*, Federal Transit Administration (www.fta.dot.gov), DOT-T-95-16, April 1995.
[42] David Gillen (2003), "The Economics of Noise," *Handbook of Transport and the Environment*, Elsevier (www.elsevier.com), pp. 81-95.
[43] TA (2003), *Alarmingly Useless: The Case for Banning Car Alarms in NYC*, Transportation Alternatives (www.tstc.org) and BanCarAlarms.Com (www.transalt.org/campaigns/caralarms).

- Swedish researcher Ulf Sandberg finds that tire/road noise is a major portion of total traffic noise.[44] He responds to the following "myths" concerning tire/road noise:
    - *Tyre/road noise has become a concern only during the last decades, say from the 1970s.* It is shown that tyre/road noise was already an important issue long ago.
    - *Tyre/road noise is an important part of vehicle noise at speeds above 50 km/h (70 for trucks).* The truth is that nowadays tyre/road noise dominates during almost all types of driving for cars and down to about 40 km/h for trucks (vehicles meeting EU requirements).
    - *Manufacturers have done a lot to reduce vehicle and tyre/road noise.* Yes, in some respects; however, it seems that vehicle noise has in some cases increased rather than decreased.
    - *Speed has great influence but it does not attract much very interest.* It is shown that there are unexpected relations between speed-related factors and that these can be useful in data presentation.
    - *Different road surfaces may give a large variation in noise levels.* True, the variation is very large, but the most common and useful surfaces are close together on the noise scale.
    - *Tyres do not differ very much in noise emission.* This is not true, the variation is large if a sufficient number of tyre types is included in the data set.
    - *Winter tyres are much more noisy than summer tyres.* This is a myth based on the past. Currently, winter tyres may be the "quiet" tyres.
    - *The width of the tyre is a very influential factor.* Essentially true: A noise-width relation covering the range from "tiny" bicycle tyres to large truck tyres is presented.
    - *Tyre/road noise from a heavy truck is far above that from a typical car.* Not true, one may find heavy trucks that emit lower tyre/road noise than some cars.
    - *Tyre/road noise is very broadband nowadays.* True and not true - current tyres emit noise very much concentrated within the 1 kHz octave. Tone correction may be considered.
    - *Quiet tyres are possible only if safety is sacrificed.* Recent results show that there is no tradeoff between low noise emission and high safety.
    - *We cannot afford to reduce tyre/road noise.* Calculation exercises are presented that suggest that low-noise tyres as well as low-noise road surfaces may be very cost effective.
    - *Tyre/road noise will be substantially reduced by the introduction of European Union noise emission limits.* Not true; the new tyre noise emission limits will be almost totally ineffective.

- The STAMINA model calculates relative noise costs of trucks and automobiles.[45]

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44 Ulf Sandberg (2001), *Tyre/Road Noise – Myths and Realities*, Swedish National Road And Transport Research Institute (www.vti.se).
45 Wisconsin Department of Transportation (1988), *Facilities Development Manual: Ch. 23, Section 25, Subject 10* (www.dot.state.wi.us); at https://trust.dot.state.wi.us/static/standards/fdm/23/23-25-10.pdf

- van Essen, et al describe various methods for calculating traffic noise costs.[46] They recommend the Impact Pathway Model, which involves these five steps:
    1. Estimate the emission from the source of noise.
    2. Determine the type of impact to human health, agriculture, natural environment, material damage etc).
    3. Estimate the number of persons, animals, plants exposed to various ambient noise levels over time.
    4. Establish the relationship between noise exposure and the various health and welfare effects; and predict ultimate noise impacts basd on these relationships.
    5. Calculate the monetary value of effect on health and other. An appropriate method would be market prices if market exists, and otherwise the willingness to pay to avoid or to accept small changes in risks if no market price is available.

- The Washington State Department of Transportation spends a maximum of $5,500 to $20,000 per exposed household to reduce highway traffic noise levels.[47] This effectively places a price on traffic noise.

- A U.K. study found significant concern about traffic vibration.[48] Along roads with 500 or more vehicles per hour during peak periods, over 50% of residents are bothered by traffic vibration. However, field studies and case studies showed only minimal and superficial structural damage caused by motor vehicle vibration

5.11.5 Variability
Noise impacts vary by vehicle type and condition, location and time. Automobiles are generally quieter than buses and motorcycles. Electric and electric /ICE hybrid vehicles generally produce low motor noise at low speeds, and wheel noise (the primary source of noise at higher speeds) comparable to gasoline and diesel vehicles. Noise costs are higher in urban areas, where there are more human ears, but an additional vehicle in quite rural areas imposes greater marginal cost than in urban traffic. Noise also impacts wildlife and so imposes environmental as well as human impacts.

5.11.6 Equity and Efficiency Issues
Noise is an external cost, and therefore inequitable and inefficient. It tends to be a particularly significant cost for urban residents, people living near highways, pedestrians and cyclists. Disadvantaged populations tend to be particularly exposed to this impact.

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[46] van Essen, et al (2004), *Marginal Costs of Infrastructure Use – Towards a Simplified Approach*, CE Delft; published in Vermeulen, et al (2004), *The Price of Transport*, CE Delft (www.ce.nl).
[47] WSDOT (1987), Directive 22-22 *Noise Evaluation Procedures for Existing State Highways*, Washington State DOT (www.wsdot.wa.gov).
[48] G.R. Watts (1990), *Traffic Induced Vibrations in Buildings*, TRRL Report #246, (www.trl.co.uk).

5.11.7 Conclusions

Noise is one of the most obvious and often-mentioned negative impacts of motor vehicle traffic. Traffic noise can discourage outdoor activities and make some locations undesirable for housing or other land uses that require quiet. People often justify moving or visiting rural areas by explaining that they enjoy the "peace and quiet." Motor vehicles, and sometimes air traffic, are dominant sources of noise in many areas.

Several studies monetize traffic noise costs. Many of these were designed to identify the marginal cost of additional vehicles on major highways and so are not sensitive to urban street traffic noise, where a few additional daily vehicle trips can significantly affect ambient noise and property values. Such studies often fail to account for non-residential impacts, and incorporate arbitrary thresholds of traffic volumes and distance between homes and streets at which noise is considered a "problem." For these reasons, such studies appear to undervalue urban traffic noise costs.

Most studies place average automobile noise costs at 0.1¢ to 2¢ per vehicle mile, but actual noise costs are probably much higher. Automobile noise costs are estimated here at 1.3¢ per mile on urban roads and rural 0.7¢ on rural roads, based on existing cost estimates increased to take into account non-residential and residual costs. Electric cars are estimated to produce 30% of the noise cost of an automobile under urban conditions, and 60% during higher speed rural driving. Diesel bus noise is estimated to be 5 times greater than an automobile. Electric bus and trolley noise are estimated to be 3 times greater than an automobile, and motorcycles are estimated to be 10 times greater than an automobile. Rideshare passengers, bicycling, walking and telecommuting impose no noise costs.

Table 5.11.7-1 **Estimate - Noise Costs (2007 U.S. Dollars per Vehicle Mile)**

Vehicle Class	Urban Peak	Urban Off-Peak	Rural	Average
Average Car	0.013	0.013	0.007	0.011
Compact Car	0.013	0.013	0.007	0.011
Electric Car	0.004	0.004	0.004	0.004
Van/Light Truck	0.013	0.013	0.007	0.011
Rideshare Passenger	0.000	0.000	0.000	0.000
Diesel Bus	0.066	0.066	0.033	0.053
Electric Bus/Trolley	0.040	0.040	0.020	0.032
Motorcycle	0.132	0.132	0.066	0.106
Bicycle	0.000	0.000	0.000	0.000
Walk	0.000	0.000	0.000	0.000
Telecommute	0.000	0.000	0.000	0.000

Automobile Cost Range

These are based on estimates cited above.

Minimum	Maximum
$0.003	$0.08

5.11.8 Information Resources

Resources listed below provide information on traffic noise impacts, costs and reduction techniques.

Ian Bateman, Brett Day, Iain Lake and Andrew Lovett (2001), *Effect of Road Traffic on Residential Property Values: A Literature Review and Hedonic Pricing Study*, Scottish Executive Development Department (www.scotland.gov.uk); at www.scotland.gov.uk/library3/housing/ertpv.pdf

CALM Network (www.calm-network.com), European Commission program.

Mark Delucchi and Shi-Ling Hsu (1998), "External Damage Cost of Noise Emitted from Motor Vehicles," *Journal of Transportation and Statistics*, Vol. 1, No. 3, (www.bts.gov/publications/jts/) October 1998, pp. 1-24. Also see Mark Delucchi, "Environmental Externalities of Motor-Vehicle Use in the US," *Journal of Transportation Economics and Policy*, Vol. 34, No. 2, (www.bath.ac.uk/e-journals/jtep/), May 2000, pp. 135-168.

EC (2005), *ExternE: Externalities of Energy - Methodology 2005 Update*, Directorate-General for Research Sustainable Energy Systems, European Commission (www.externe.info).

EU (1995), *Calculation of Road Traffic Noise*, Directorate for Noise and Traffic, European Union (www.ec.europa.eu); at www.xs4all.nl/~rigolett/ENGELS/index.html

Environmental Valuation Reference Inventory (www.evri.ca) is a searchable storehouse of empirical studies on the economic value of environmental benefits and human health effects.

U.S. Federal Highway Administration Documents (www.fhwa.dot.gov):

- (1997), *Highway Traffic Noise in the US* (www.nonoise.org/library/highway/probresp.htm)
- (1980), *Highway Traffic Noise* (www.nonoise.org/library/highway/traffic/traffic.htm)
- (1999), *The Environmental Guidebook* (www.fhwa.dot.gov/environment/guidebook/index.htm)
- Highway Traffic Noise (www.fhwa.dot.gov/environment/htnoise.htm)

David Gillen (2007) *Noise and the Full Cost Investigation in Canada: Final Report - Estimation of Noise Costs due to Road, Rail and Air Transportation in Canada*, Transport Canada (www.tc.gc.ca); at www.tc.gc.ca/pol/en/aca/fci/transmodal/menu.htm

Paul A. Kaseloo and Katherine O. Tyson (2006), *Synthesis of Noise Effects on Wildlife Populations*, Federal Highway Administration (www.fhwa.dot.gov); at www.fhwa.dot.gov/environment/noise/effects/index.htm

Richard T.T. Forman, et al (2003), *Road Ecology*, Island Press (www.islandpress.com).

INFRAS and IWW (2004), *External Costs of Transport – Update Study*, Community of European Railway Companies (www.cer.be) and the International Union of Railways (www.uic.asso.fr).

M. Maibach, et al. (2008), *Handbook on Estimation of External Cost in the Transport Sector*, CE Delft (www.ce.nl); at http://ec.europa.eu/transport/costs/handbook/doc/2008_01_15_handbook_external_cost_en.pdf

Matthew McCallum-Clark, Rochelle Hardy and Malcolm Hunt (2006), *Transportation and Noise: Land Use Planning Options for a Quieter New Zealand*, Land Transport New Zealand Research Report 299 (www.ltsa.govt.nz); at www.ltsa.govt.nz/research/reports/299.pdf

The *Noise Pollution Clearinghouse* (www.nonoise.org) is a US based non-profit organization with extensive online noise related resources.

SYLVIE (www.sylvie.at) is developing practical methods to evaluate and alleviate urban noise.

TRB (2005), "Transportation Noise: Measures and Countermeasures," *TR News* (special issue), Transportation Research Board (www.trb.org), Sept./Oct. 2005; at http://trb.org/news/blurb_detail.asp?id=5546.

USEPA (1999), *Indicators of the Environmental Impacts of Transportation*, USEPA (www.epa.gov).

van Essen, et al (2004), *Marginal Costs of Infrastructure Use – Towards a Simplified Approach*, CE Delft (www.ce.nl).

Vermeulen, et al (2004), *The Price of Transport: Overview of the Social Costs of Transport*, CE Delft (www.ce.nl).

WHO (1999), *Guidelines for Community Noise*, World Health Organization (www.who.int); at www.who.int/docstore/peh/noise/guidelines2.html; and WHO (2000) *Transport, Environment and Health*, WHO European Series #89 (www.who.int); at www.euro.who.int/document/e72015.pdf.

Anming Zhang, Anthony E. Boardman, David Gillen and W.G. Waters II (2005), *Towards Estimating the Social and Environmental Costs of Transportation in Canada*, Centre for Transportation Studies, University of British Columbia (www.sauder.ubc.ca/cts), for Transport Canada; at www.sauder.ubc.ca/cts/docs/Full-TC-report-Updated-November05.pdf.