5.6 Roadway Facility Costs

This chapter examines public expenditures on roadway facilities, including construction, maintenance and operating costs, and how these costs are allocated to different types of vehicles. Roadway costs not borne by user charges (special fuel taxes, vehicle registration fees and road tolls) are considered external costs.

5.6.1 Chapter Index

5.6.2 Definition

Roadway costs include public expenditures to build and maintain roadway facilities, including land, road construction, maintenance, and operations. *Cost recovery* refers to the portion of roadway costs that are borne by users through special user fees and taxes, such as road tolls, special fuel taxes, and vehicle registration fees. To avoid double-counting costs in Chapter 5.1, only the portion not paid by road user charges is included in the final cost values of this chapter. The opportunity cost of roadway land is included in chapter 5.7, and municipal services such as traffic policing are included in chapter 5.8.

5.6.3 Discussion

Vehicle travel requires a network of roads. Roadway costs include the cost of land, construction, financing, maintenance and operations. Roadway costs are relatively easy to measure because they are mostly reflected in government budgets and agency reports. Table 5.6.3-1 lists various roadway cost categories and their share of total US roadway costs.

Table 5.6.3-1 **Roadway Expenditures**[1]

	Portion of Total
Maintenance & Operations	26%
Highway Capacity Expansion	23%
Highway Reconstruction, Rehabilitation & Restoration	19%
Highway Administration	9%
Highway Patrol & Safety	8%
Local Road Capital Improvements	8%
Interest on Debt	4%
Other	3%

Cost Allocation

Cost allocation (also called *cost responsibility*) refers to methods used to calculate the share of roadway costs imposed by different vehicle classes, and how these costs compare with roadway user payments by that class.[2, 3] Various methods are used to calculate roadway construction and maintenance costs, including indirect costs such as the share of general agency administrative costs that should be included when calculating the costs of a spective program or project.[4]

User payments refers to special fees and taxes charged to road users, including tolls, fuel taxes, registration fees and weight-distance fees, but does not include general taxes applied to vehicles and fuel.[5] Various perspectives and methods are used to determine which costs to assign to specific vehicles. Different countries use apply different scope of analysis and methodologies when calculating roadway costs for investment and pricing purposes.[6]

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[1] FHWA (1995), *1995 Status of the Nation's Surface Transportation System: Conditions & Performance*, (www.fhwa.dot.gov), p. 8. Also see Leonard Goldberg (1996), "Local Government Highway Finance Trends," *Public Roads*, Summer, p. 27.

[2] Joseph Jones and Fred Nix (1995), *Survey of the Use of Highway Cost Allocation in Road Pricing Decisions*, Transportation Association of Canada (www.tac-atc.ca); FHWA (1997), *Federal Highway Cost Allocation Study*, USDOT (www.fhwa.dot.gov); at www.fhwa.dot.gov/policy/hcas/summary/index.htm ; TC (2006), *Allocation Options*, Transport Canada Policy Group (www.tc.gc.ca/pol).

[3] Patrick Balducci and Joseph Stowers (2008), *State Highway Cost Allocation Studies: A Synthesis of Highway Practice*, NCHRP Synthesis 378; at http://itd.idaho.gov/taskforce/resources/nchrp_syn_378.pdf.

[4] Cambridge Systematics (2011), Determining Highway Maintenance Costs, NCHRP Report 688, Transportation Research Board (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_688.pdf.

[5] Tony Dutzik, Benjamin Davis and Phineas Baxandall (2011), *Do Roads Pay for Themselves? Setting the Record Straight on Transportation Funding*, PIRG Education Fund (www.uspirg.org); at www.uspirg.org/news-releases/transportation-news/transportation-news/washington-d.c.-myth-busted-road-costs-not-covered-by-gas-taxes.

[6] Franziska Borer Blindenbacher (2005), *Study of Methods of Road Capital Cost Estimation and Allocation by Class of User in Austria, Germany and Switzerland*, Transport Canada (www.tc.gc.ca); at www.tc.gc.ca/policy/report/aca/fullcostinvestigation/road/tp14494/tp14494.htm.

Roadway costs can be categorized in various ways for cost allocation analysis:

- *Short Run Marginal Cost* (SRMC) only includes costs imposed using current capital resources, ignoring other costs, such as vehicle and roadway capital costs.
- *Long Run Marginal Cost* (LRMC) includes all costs imposed, including past investment costs and the opportunity cost of land and other resources, but ignores *sunk costs* (unrecoverable costs already incurred).
- *Fully Allocated Costs* (FAC, also called *cost recovery*) includes all infrastructure costs, including sunk costs, allocated among users in some way that is considered equitable.
- *Pay-As-You-Go* (PayGo) means that financial investments made each year are allocated to users as a group during that year, so no funds need be borrowed.

For example, *Short Run Marginal Cost* only considers immediate costs, such as road wear and any congestion delay, accident risk and environmental impacts imposed by vehicle traffic. *Long Run Marginal Cost* includes all ongoing costs to build, maintain and expand infrastructure as needed, but ignores sunk costs, such as past construction costs, and often the value of land devoted to such facilities (although land almost always has an opportunity cost and so should be included in LRMC).

Some economists consider short-run marginal cost (SRMC) pricing (road users only pay directly for incremental maintenance and operating costs, with long-run costs financed through general taxes) most efficient, but there are reasons to recover all roadway costs from users using Long Run Marginal Cost or Fully Allocated Cost pricing: for the sake of horizontal equity (reflecting the principle that consumers should "get what they pay for and pay for what they get" unless subsidies are specifically justified), and economic neutrality (since most products are priced for cost recovery, so failing to charge motorists full costs underprices road transport relative to other goods).[7]

Fully Allocated Costs (FACs) include all infrastructure financial expenditures. Costs imposed within a group are often excluded, such as congestion, accident and environmental impacts imposed and borne by road users as a group. This means that costs depend on how groups are defined, for example, whether congestion or risks imposed by one vehicle or motorist type on another, are considered externalities.

Table 5.6.3-2 summarizes the costs and appropriate charges based on various roadway cost allocation perspectives.

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[7] Gerhard Metschies (2005), *International Fuel Prices 2005, with Comparative Tables for 172 Countries*, German Agency for Technical Cooperation (www.gtz.de/en); at www.internationalfuelprices.com

Table 5.6.3-2 **Comparison of Costs and Charge Concepts**[8]

Category	SRMC	LRMC	FAC	PayGo
Costs				
Return on capital.	Not relevant	Not relevant	Return on capital employed.	Not relevant
Infrastructure costs	Facility wear caused by use.	Facility wear caused by use, and capital costs to increase capacity to accommodate growing demand.	All ongoing infrastructure costs (operations, maintenance and depreciation).	All costs (operating and capital) incurred during a year.
Service provider operating costs	Cost of an additional vehicle km.	Cost of an additional vehicle km.	All costs associated with providing services.	All costs.
Congestion	Costs imposed by one user on other transport system users.	Not included if capacity expansion leaves existing traffic unaffected.	Not relevant, since this cost is imposed and borne by infrastructure users as a group.	Not relevant, since this cost is imposed and borne by infrastructure users as a group.
Mohring Effect[9]	Benefits of increased public transport service frequencies due to additional demand.	Benefits of increased public transport service frequencies due to additional demand.	Not relevant, since this impact is imposed and borne by infrastructure users as a group.	Not relevant, since this impact is imposed and borne by infrastructure users as a group.
Accidents	External crash risk costs of an additional unit of travel.	External crash risk costs of an additional unit of travel.	External costs attributed to user groups on the basis of responsibility.	Not relevant
Environmental Costs	Cost of an additional unit of travel.	Cost of an additional unit of travel.	Costs of total vehicle travel.	Not relevant
Charges				
Fuel excise tax and road user charges	Revenue associated with an additional vehicle km.	Revenue associated with an additional vehicle km.	Total revenues from fuel taxes and road user charges.	Total revenues from fuel taxes and road user charges.
Motor vehicle registration and licensing.	If related to additional vehicle travel.	If related to additional vehicle travel	All motor vehicle registration charges	All motor vehicle registration charges
Goods and Services Tax (GST)	On all costs.	On all costs.	On all costs.	On all costs.
Fares, fright tariffs and traffic fines.	Associated with an additional unit of travel.	Associated with an additional unit of travel.	All fares, taxes.	All fares, taxes.

This table summarizes differences between various categories of costs and charges.

8 Booz Allen Hamilton (2005), *Surface Transport Costs and Charges Study*, Ministry of Transportation New Zealand (www.transport.govt.nz).

9 The Mohring effect is a technical property of transit systems demonstrating increasing returns with increased service frequency and ridership. See, Mohring, H. (1972), "Optimization and Scale Economies in Urban Bus Transportation," *American Economic Review*, pp. 591-604.

Cost Factors

A vehicle's roadway costs are affected by three general factors:[10]

1. *Strength required and damage inflicted.* High volumes of heavy vehicles imply higher road and bridge construction standards and costs than lighter vehicles. Roadway wear also increases exponentially with axle weight (between the third and fourth power), so heavy vehicles impose much greater maintenance and repair costs than lighter vehicles. A heavy truck imposes roadway costs equal to hundreds or thousands of light vehicles, depending on weight and road type. Studded tires also significantly increase road repair costs.

2. *Space required.* Larger vehicles require more road space, for example wider lanes. Also, as speeds increase so does the "shy distance" required between vehicles and other objects, so higher speed traffic requires wider lanes, greater road capacity and more clearance. Road space requirements are measured in "passenger car equivalents," or PCEs. A large truck or bus typically imposes 2-5 PCEs, and more when ascending a steep incline.

3. *Design requirements*. Faster traffic requires higher roadway design speeds and impose greater risk, which increases safety requirements such as barriers and clear space.

The incremental costs of building stronger pavements, wider roads and higher design speeds can be assigned to vehicles according to their weight, size and speed. The incremental costs of increasing roadway capacity should generally only be assigned to peak-period trips that contribute to congestion. Some roadway costs, such as planning, law enforcement and lighting costs are not clearly related to a particular vehicle attribute, and any remaining costs are considered *common costs* that can be prorated based on other costs or allocated based on mileage.

Internal and External Costs

Roadway expenditures not funded through user fees can be considered an external cost since people pay regardless of how much they use roads. Some automobile industry advocates claim that motor vehicle user taxes exceed roadway expenditures,[11] but their analysis violates cost allocation principles by excluding local roadway expenditures and including general taxes, rather than just special user fees.[12]

Table 5.6.3-3 summarizes U.S. roadway user fees and expenditures by level of government in 2008. This indicates that user fees funded only about half of total roadway costs. General taxes spent on roads average about 3.3¢ per vehicle mile. Vehicle user fees would need to double to fully fund roadway costs.

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[10] Kenneth A. Small, Clifford M. Winston, and Carol A. Evans (1989), *Road Work: A New Highway Pricing and Investment Policy*, Brookings Institution Press (www.brookings.edu).

[11] Todd Litman (2003), *Evaluating Criticism of Transportation Costing*, VTPI (www.vtpi.org); at www.vtpi.org/tca/tca08.pdf.

[12] Urban Institute (1990), *Rationalization of Procedures for Highway Cost Allocation*, Trucking Research Institute.

Table 5.6.3-3 **Roadway Expenditures by Level of Government** (2008 Billions)[13]

	User Fees	Other Taxes	Total
Federal	$30.8 (74%)	$11.1 (26%)	$41.9 (100%)
State	$59.0 (60%)	$38.7 (40%)	$97.7 (100%)
Local	$4.3 (8%)	$48.8 (92%)	$53.1 (100%)
Total	*$94.1 (49%)*	*$98.6 (51%)*	*$192.7 (100%)*
Per vehicle-mile (2,974 B. VMT)	*3.2¢/mile*	*3.3¢/mile*	*7.5¢/mile*

In 2008, vehicle user fees totaled $94.1 billion, about half of the $192.7 billion spent on roadways. Total expenditures averaged 7.5 cents per vehicle-mile.

Roadway costs are often greater than indicated by current expenditures due to deferred maintenance. Annual roadway expenditures would need to increase at least 13% to maintain current system performance.[14] New public accounting requirements (GASB Statement 34) may in the future provide additional information on the value of roadway facilities and costs associated with deferred investments.[15] Roadway agencies tend to undervalue capital costs compared with what is indicated by standard accounting procedures because capital expenditures are treated as current costs and all past expenditures are considered sunk.[16] Applying business principles, road users would be charged for capital expenditure return on investment.[17] As described by Lee:[18]

> Current highway finance practice finances most improvements out of current revenues, eliminating the need for borrowing. If highway users — who are also highway investors — don't have to pay interest on capital improvements, why should they be charged for it? The reason is that money deposited in a highway trust fund earns interest at whatever rate the U.S. Treasury is paying, and that interest is foregone when money is spent. There is no way to pretend that capital investments have no opportunity cost to the funds committed to them. Equally important, the amount spent one year bears little relationship to the value of the capital consumed in that year. If the system is wearing down faster than it is being rebuilt, for example, current users are living off of previous users/taxpayers who built up the capital stock.
>
> A capital asset that continues to function as a highway should be earning revenues at least as great as the interest on the invested capital plus depreciation, plus operating costs. To earn less implies that the long run costs are not justified, and the road ought to be phased out of use. What is desired is a capital cost that includes actual depreciation plus interest, and which will recover the replacement cost of the asset over its lifetime.

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[13] FHWA (2008), *Highway Statistics*, (www.fhwa.dot.gov), Table HF-10.
[14] USDOT (1997), *1997 Status of the Nation's Surface Transportation System; Report to Congress*, US Department of Transportation (www.dot.gov).
[15] Anthony J. Kadlec and Sue McNeil (2001), "Applying Governmental Accounting Standards Board Statement 34; Lessons from the Field," *Transportation Research 1747* (www.trb.org), pp. 123-128.
[16] Herbert Mohring and Mitchell Harwitz (1965), *Highway Benefits: An Analytical Framework*, Northwestern University Press (http://nupress.northwestern.edu/). The authors emphasizes that road user charges should incorporate amortized values for all construction, maintenance, and depreciation costs.
[17] Douglass Lee (1997), "New Zealand's Land Transport Pricing Study," *Streets for People*, No. 4, March 1997, p. 8.
[18] Douglass Lee (1995), *Full Cost Pricing of Highways*, Volpe National Transportation Systems Center (www.volpe.dot.gov), p.13.

"Think Drivers Pay The Cost Of Roads? It's A Myth"
Erik Hare, *Star Tribune*, 7 Sept. 2003

We tend to assume that driving pays entirely for itself, and that's reason enough for government to favor roads over other transportation choices. Not only do drivers pay for their cars, we believe, but also for gasoline that is taxed enough to cover the construction and maintenance of all the roads we'll ever need. But this is a myth.

Minnesota's 20-cent gasoline tax would have to rise by 39 cents to cover all of the state's current road-related expenses. To start building the roads we actually need in order to deal with congestion, the tax would have to rise 42 cents beyond that, pushing the price of gasoline beyond $2.60 a gallon.

Clearly, somebody besides the driver is paying for Minnesota's roads. Drivers – through gasoline taxes, car registration fees and sales taxes on vehicles – actually pay only 62% of the costs of roads. General taxpayers "subsidize" the rest, no matter how much or little they drive. Because of this arrangement, a good portion of Minnesota's demand for roads is forced to compete with the whole array of other pressing government needs. This competition now threatens the integrity of our road system, especially in busy urban areas. It also chokes off opportunities to provide other viable transport choices, like transit.

The problem's roots date back to Model T days. Dirt roads were fine for horses, but muddy roads were terrible for cars. The political cry to "Get the farmers out of the mud!" led to changing the state Constitution in 1920. A system of paved trunk highways, plus help for county and city roads, was to be funded by a gasoline tax and a vehicle registration fee. Thus pavement replaced dirt.

Much has changed in 83 years, but the outline of that financing structure remains in place. A formula for the distribution of state gasoline tax revenues (62% to the state, 29% to counties and 9% to cities) took effect in 1956, but that hasn't changed either, even as the state has become considerably more urban and our economy more diverse and sophisticated. We still have a transportation financing scheme designed mostly to get farmers out of the mud.

Thanks to this antiquated system, Minnesotans who tend to drive the least -- urban residents -- tend to pay a disproportionate cost for roads. Not only is this unfair; a heavy reliance on property taxes leaves the entire road system vulnerable to other budget constraints.

St. Paul offers a good case study. Public Works is the largest department in city government, accounting for more than a third of municipal operating costs. It spends most of its money on roads – $67.3 million last year. But only about 30% of that comes from driver-generated income on parking, snow-plowing fees and so on. The other 70% comes from general revenues, assessments based on street frontage and type of property, and an infusion of $10.3 million from the city's general fund -- money that must compete with police and fire operations and other pressing needs. That's still not the whole picture. Debt service is a major part of city spending. This year, 36% of St. Paul's $78 million in bond repayment will go to cover road projects. That's an additional $19.9 million draw on the city's hard-pressed general fund.

The bottom line is this: Only 24% of the cost of St. Paul's roads is borne by driver-generated taxes and fees. The other 76% is a subsidy from general revenues and property assessments. There's no reason to believe that St. Paul's situation is atypical for cities and older suburbs.

Roadway Capacity Expansion Costs

Roadway costs can be divided into two major categories: new construction that increases road capacity, and maintenance and operation of existing roads. Table 5.6.3-4 summarizes typical roadway project costs. These values are occasionally updated.[19] Urban highway capacity expansion tends to increase over time, due to increasing land costs and because the cheapest projects have already been implemented. As discussed below, costs are also closely linked to oil prices.

Table 5.6.3-4 **Roadway Project Costs** (Thousands of 2000 US$ per lane-mile)[20]

	Freeways		Other Divided Highways		Undivided Highways	
	Built-Up Areas	Outlying Areas	Built-Up Areas	Outlying Areas	Built-Up Areas	Outlying Areas
Right-of-way for new lanes	$632	$253	$570	$229	$514	$209
Construction of new lanes	$2,541	$2,138	$2,288	$1,922	$2,057	$1,728
Reconstruction with new lanes	$3,173	$2,391	$2,858	$2,152	$2,572	$1,936
Reconstruction with wider lanes	$2,330	$1,682	$2,099	$1,514	$1,889	$1,362
Intersections	$15,000	$10,000	$2,000	$4,000	$500	$100
Pavement reconstruction	$1,628	$1,466	$1,471	$1,321	$1,326	$1,190
Major widening	$1,300	$1,043	$1,170	$940	$1,052	$845
Minor widening	$940	$721	$845	$648	$760	$584
Resurfacing & shoulder improvements	$443	$388	$400	$350	$361	$314
Resurfacing	$193	$178	$175	$158	$157	$145

Urban highway capacity expansion typically costs $8-12 million per lane-mile for land acquisition, lane pavement and intersection reconstruction.[21] This represents an annualized cost of $300,000-700,000 per lane-mile (assuming a 7% interest rate over 20 years). Dividing this by 4,000 to 8,000 additional peak-period vehicles for 250 annual commute days indicates a cost of 15-75¢ per additional vehicle-mile of travel, plus 7-15¢ per vehicle-mile for road maintenance and traffic services, indicating roadway costs of $3-15 for a typical commute trip that involves 20-miles of travel under congested urban-peak roadway conditions. Increasing highway capacity in built up areas of large cities such as Washington DC, Los Angeles and Boston can cost even more.[22]

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[19] Mohammed Alam, Darren Timothy and Stephen Sissel (2005), "New Capital Cost Table for Highway Investment Economic Analysis," *Transportation Research Record 1932*, TRB (www.trb.org), pp. 33-42.

[20] Cambridge Systematics, et al. (1992) *Characteristics of Urban Transportation Systems - Revised Edition September 1992*, FTA, USDOT (www.fta.dot.gov), 1992, Table 4-16. Original Source: Jack Faucett Associates; *Highway Economic Requirements System Technical Report*, Federal Highway Administration, 1991. Based on 1989 to 2000 inflation rate of 1.39. The *Price Trends in Federal-Aid Highway Construction* (a quarterly report published by the FHWA) provides information on highway construction cost trends.

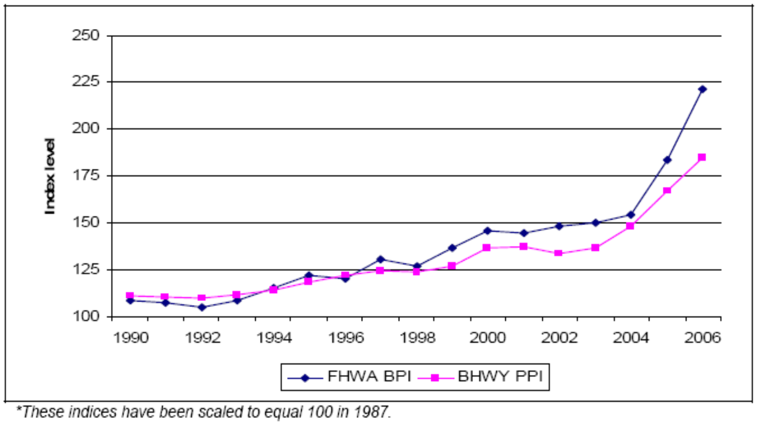
[21] For an example of project costs see WSDOT (2005), *Highway Construction Costs: Are WSDOT's Highway Construction Costs in Line with National Experience?* (www.wsdot.wa.gov); at www.vtpi.org/WSDOT_HighwayCosts_2004.pdf.

[22] Patrick Decorla-Souza and Ronald Jensen-Fisher (1997), "Comparing Multimodal Alternatives in Major Travel Corridors," *Transportation Research Record 1429* (www.trb.org), pp. 15-23, Table 1.

Construction Cost Inflation

Roadway construction cost inflation can be tracked using the U.S. Federal Highway Administration's Bid Price Index (FHWA BPI) and the Bureau of Labor Statistics's Bridge and Highway construction Producer Price Index (BHWY PPI). Roadway construction and maintenance costs increased rapidly from 2003 through 2006 due to rising cost of labor and commodities used in highway projects, such as fuel, steel, cement and asphalt.

Figure 5.6.3-1 US Highway Construction and Maintenance Cost Indices[23]



Construction costs increased rapidly between 2003 and 2006.

Other Road Uses

It is sometimes argued that not all roadway costs should be charged to motorists. Even residents who never drive use road access for delivery of goods and services, walking and bicycling, and for utility lines. This can be addressed by establishing a standard of "basic access" that is unrelated to driving. In practice this need can usually be satisfied by a single lane of light pavement, which is the quality of road typically chosen when users pay for their own driveway, and which exist in pedestrian cities and campus-type developments. Roadway costs beyond this can be allocated to motor vehicle use.

Since most communities have well-developed roadway systems that easily satisfy basic access, the need to increase roadway capacity usually results from motor vehicles' relatively large space requirements.[24] Even pedestrian and bicycle facility costs could be charged to driving if motor vehicle traffic is considered to degrade bicycling and walking environments, creating the need for separate facilities. This implies that most current road expenditures are the responsibility of motor vehicle users.

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[23] FWHA (2007), *Growth in Highway Construction and Maintenance Costs,* Federal Highway Administration (www.fhwa.dot.gov); at www.oig.dot.gov/StreamFile?file=/data/pdfdocs/Growth_in_Highway_Construction_and_Maintenance_Costs_Final.pdf.

[24] Todd Litman (2000), *Transportation Land Valuation; Evaluating Policies and Practices that Affect the Amount of Land Devoted to Transportation Facilities*, Vvtp (www.vtpi.org); at www.vtpi.org/land.pdf.

5.6.4 Estimates

Note: all values are in U.S. dollars unless otherwise indicated.

Summary Table of Road Cost Estimates

Table 5.6.4-1 **Road Cost Estimate Summary Table – Selected Studies**

Publication	Costs	Cost Value	2007 USD
Texas DOT (2008)	Routine Maintenance	$4,400 per lane mile (2004)	$4,840
	Percentage of costs covered by fuel taxes and fees, selected segments	13 – 93% Average 34%	N/A
	State fuel tax gap	$0.08 - $4.73/gallon Average $2.35/ gallon*	N/A
USDOT (1997)	Automobiles - external	$0.009 per vehicle mile (1997*)	$0.012
	Automobiles - total	$0.035	$0.045
	Combination Trucks - external	$0.044	$0.057
	All Vehicles - external	$0.010	$0.013
Delucci (2007)	External	$0.010 – 0.035 per vehicle mile (2005)	$0.011-$0.037
Florida DOT (2003)	Roadway Construction – 4 lane urban	$4,765,100 per mile*	$5,384,563
	Routine Annual Maintenance – 4 lane urban	$58,500 per mile	$66,105
Lee (1995)	Subsidy (external cost)	$0.018 per mile*	$0.024
Forkenbrock (1999)	Trucks – uncompensated roadway costs	$0.025 per ton-mile*	$0.031

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[25]*. * Indicates that the currency year is assumed to be the same as the publication year.*

[25] Note that CPI is not the only way to adjust for inflation and results can vary significantly with different methods, see: Samuel H. Williamson (2008), "Six Ways to Compute the Relative Value of a U.S. Dollar Amount, 1790 to Present," MeasuringWorth (www.measuringworth.com).

Resources

The following resources can help develop accurate roadway project cost projections:[26]

- Consolidated Transportation Program Cost Estimate Program, Maryland DOT (www.sha.state.md.us/businesswithsha/costEstBudgets/CTP/oppe/consolidated_trans.asp).
- Project Development Procedures Manual, California State DOT (www.dot.ca.gov/hq/oppd/pdpm/pdpmn.htm).
- Construction Cost Estimation Manual, New Jersey DOT (www.state.nj.us/transportation/eng/CCEPM).
- Transportation Costs Reports, Florida DOT (www.dot.state.fl.us); at www.dot.state.fl.us/planning/policy/costs/default.asp.
- Transportation Estimators Association (http://tea.cloverleaf.net).
- Transport User Group (http://tug.cloverleaf.net)—an independent association of State DOT personnel involved in cost estimating
- Project Cost Estimating: A Synthesis of Highway Practice, NCHRP Report 20-7, TRB (http://cms.transportation.org/sites/design/docs/Project%20Cost%20Estimating%20Report.pdf) provides a summary of current highway cost-estimating practices.
- The FHWA Office of Planning (www.fhwa.dot.gov/hep) provides information on cost-estimating practices and approaches used by transport planning organizations.
- The American Road and Transportation Builders Association (www.artba.org) provides monthly and annual transportation construction material price reports at www.artba.org/economics_research/recent_statistics/prod_price_index/prod_price_index.htm.

General Studies

- The Texas Department of Transportation developed a methodology for determining the proportion of road costs covered by fuel taxes and vehicle registration fees. *The Highway Construction Equity Gap* (2008) examines seven highway segments from 2009 to 2044 and forecasts that revenues would cover between 13 and 93% of costs, with an average of 34%, at present tax levels. State motor fuel taxes would need to be increased by between $0.08 and $4.73 per gallon, with an average value of $2.35, to cover 100% of costs. Routine maintenance costs are estimates at $4,400 per lane mile with a 6% annual growth factor. Note that this study covers selected highway segments only and does not claim to be representative of the state highway network as a whole.[27]

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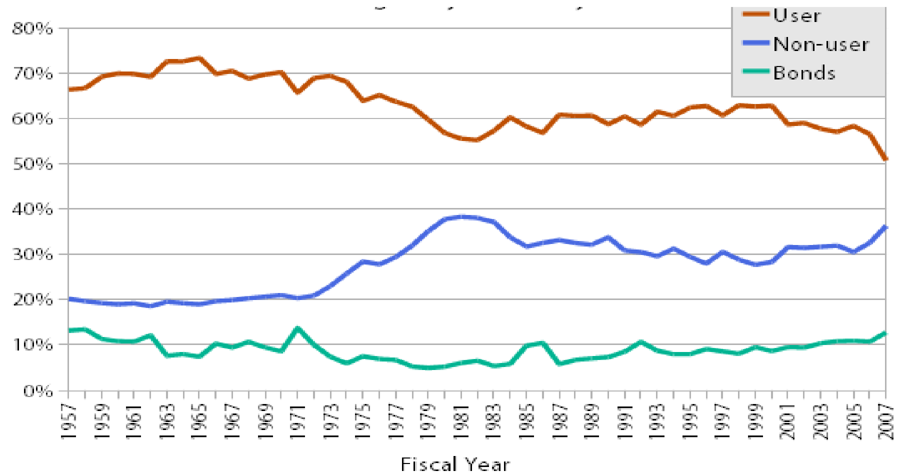
[26] Jim Sinnette (2004), "Accounting for Megaproject Dollars," *Public Roads*, FHWA (www.fhwa.dot.gov), July/August 2004; at www.tfhrc.gov/pubrds/04jul/07.htm.
[27] Cambridge Systematics (2008), *The Highway Construction Equity Gap*, Texas Department of Transportation (www.keeptexasmoving.com).

- Analysis of Federal Highway Statistics (www.fhwa.dot.gov/policy/ohpi/hss/index.cfm) found that the portion of U.S. roadway expenses paid by user fees declined significantly between 1960 and 2007.[28] In 2007, user fees (fuel taxes, vehicle registration fees and tolls) financed only 51% of the $193 billion highway construction and maintenance expenditures, down from 61% ten years earlier, the rest came from income, sales and property taxes, and bonds. Not all user fees collected are spent on highways. Of the 18.4¢ per gallon federal tax on gasoline, 2.86¢ are allocated to public transit and 0.1¢ per gallon for leaking fuel storage tank cleanup, and between 1990 and 1997 a portion of federal fuel taxes were used to reduce budget deficits. However, even if those funds were fully devoted to highways, total user fee revenue accounted for only 65% of all 2007 highway funding, down from 84% in 1997 and 77% in 1967.

Figure 5.6.4-1 **Share of Highway Funds By Source** (Subsidy Scope)



- The US Federal Highway Administration found that that highway construction and maintenance costs grew three times faster from 2003 through 2006 than any other time since 1990. These increases are largely attributed to cost escalation of inputs such as steel, cement and asphalt. The study notes that the price increases of cement and asphalt are largely due to the increased price of oil during this period. The report states that "A dollar will have lost between 37 and 60 percent of its value between 2005 and 2009, if highway project inflation continues at its 2006 pace."[29]

- The Bureau of Economic Analysis (BEA) provides data on the present value of total U.S. capital expenditures on streets and highways (depreciated capital cost borne by taxpayers to improve streets and highways) from 1925 to 2004, as shown in Table 5.6.4-2. Roads and streets are the largest category of "Government Fixed Assets."

[28] Subsidy Scope (2009), *Analysis Finds Shifting Trends in Highway Funding: User Fees Make Up Decreasing Share* Subsidy Scope (www.subsidyscope.com); at www.subsidyscope.com/transportation/highways/funding.
[29] FWHA (2007), *Growth in Highway Construction and Maintenance Costs*, FHWA (www.fhwa.dot.gov); at www.oig.dot.gov/StreamFile?file=/data/pdfdocs/Growth_in_Highway_Construction_and_Maintenance_Costs_Final.pdf.

Table 5.6.4-2 **Roadway Cost Responsibility Per Mile** (1997 Dollars)[30]

	2000	2001	2002	2003	2004
Federal	37.9	38.5	39.0	38.9	40.3
State and local	1,399.4	1,461.9	1,529.5	1,571.5	1,647.9
Total government	1,437.3	1,500.4	1,568.5	1,610.4	1,688.2

- Table 5.6.4-3 summarizes the results of the most recent (1997) federal highway cost allocation study, showing cost responsibility, roadway user payments and external costs (roadway costs not paid by vehicle user payments) averaged over total travel.

Table 5.6.4-3 **Roadway Cost Responsibility Per Mile** (1997 Dollars)[31]

Vehicle Class	VMT (million)	Federal Costs	State Costs	Local Costs	Total Costs	Total User Payments	External Costs
Automobiles	1,818,461	$0.007	$0.020	$0.009	$0.035	$0.026	$0.009
Pickups and Vans	669,198	$0.007	$0.020	$0.009	$0.037	$0.034	$0.003
Single Unit Trucks	83,100	$0.038	$0.067	$0.041	$0.146	$0.112	$0.034
Combination Trucks	115,688	$0.071	$0.095	$0.035	$0.202	$0.157	$0.044
Buses	7,397	$0.030	$0.052	$0.036	$0.118	$0.046	$0.072
All Vehicles	*2,693,844*	*$0.011*	*$0.025*	*$0.011*	*$0.047*	*$ 0.036*	*$0.010*

- The American Association of Highway and Transportation Officials (AASHTO) *Bottom Line* report, estimates that if U.S. annual vehicle travel growths at 1.4% annually it must spend $144 billion for roadway expansion, repair and maintenance, but if vehicle travel only grows 1.0% annually, required expenditures decline to $120 billion.[32] This suggests that a 0.4% growth in vehicle travel, which totals about 12 billion annual vehicle-miles, causes $24 billion in annual congestion and road maintenance costs, which translates into about $2 per avoided VMT.

- Apogee Research calculated roadway facility costs to range from 5.4¢ per automobile mile for Boston expressway driving, to 0.6¢ for non-expressway driving in Portland, ME.[33] They found that maintenance is being deferred, adding 1.2¢ per expressway vehicle mile, and 2.1¢ for non-expressway driving.

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30 BEA (2004), *Current-Cost Net Stock of Government Fixed Assets: Table 7.1B.*, Bureau of Economic Analysis, Department of Commerce (www.bea.gov); at www.bea.gov/bea/dn/FA2004/SelectTable.asp

31 USDOT (1997), *1997 Federal Highway Cost Allocation Study*, USDOT (www.dot.gov), based on data from tables II-6, IV-11, V-21; at www.fhwa.dot.gov/policy/hcas/summary/index.htm

32 AASHTO (2014), *The Bottom Line*, American Association of State Highway and Transportation Officials (www.aashto.org); at http://tinyurl.com/o5g23b9.

33 Apogee Research (1994), *The Costs of Transportation: Final Report*, Conservation Law Foundation (www.clf.org), pp. 121-137, 155-157.

- A 2007 Transport Canada study allocated construction and maintenance costs for various types of roads to various vehicle classes for each province.[34] The general results are similar to US studies, but the study identifies heavily loaded transit buses as a significant cost on some urban roadways.

- A New Zealand roadway cost allocation study that included roadway facility costs, accident and pollution externalities, concluded that cars pay 64% of their costs, trucks 56% of costs, and buses 68% of costs.[35] Cost recovery was higher (87%) on state highways than on local roads (50%). Rail transport is found to recover 77% of costs.

- A study of public infrastructure by Statistic Canada found that roads and bridges made up the bulk (39.9%) of local, provincial and federal government-owned infrastructure in Canada.[36] Road infrastructure per capita peaked at $3,019 in 1979 and declined to $2,511 in 2005 (in constant 1997 dollars).

- A studded tire removes ½- to ¾-ton of roadway pavement during a typical 30,000-mile operating live, imposing an estimated $8-15 per tire in direct rutting costs and $40-50 per tire if the pavement adjacent to the rutted lane is also replaced.[37]

- Transport Canada reports that in 2009–10, all levels of Canadian government spent $28.9 billion on roads and collected $12.1 billion in fuel taxes and $4.4 billion in other transport user fees, indicating that in Canada, road user fees cover about 64% of costs.[38]

- Automobile user payments (fuel taxes and vehicle registration fees) cover 56% of roadway network expenditures in Wisconsin.[39] Fuel taxes would need to increase approximately 35¢ per gallon to fund all current road expenses.

- Delucchi estimates the annualized costs of public roadways (provided by all levels of government) total $98-177 billion, averaging 4.5-8.0¢ per vehicle mile.[40] A more recent study by the author indicates that 2005 U.S. motor vehicle tax and government fee

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[34] Applied Research Associates (2007); *Estimation of Road Cost Allocation Between Light Vehicles and Heavy Vehicles in Canada*, Transport Canada (www.tc.gc.ca); at www.bv.transports.gouv.qc.ca/mono/0965485.pdf.
[35] Booz Allen Hamilton (2005), *Surface Transport Costs and Charges Study*, Ministry of Transportation New Zealand (www.transport.govt.nz).
[36] Francine Roy (2008), *From Roads to Rinks: Government Spending on Infrastructure in Canada, 1961 to 2005*, Isights on the Canadian Economy Research Papers, Statistics Canada (http://ssrn.com/abstract=1407694).
[37] BRCT (2000), *Accords and Options*, Washington State Blue Ribbon Commission on Transportation (www.leg.wa.gov), May 2000, p 15.
[38] TC (2010), *Transport In Canada: An Overview*, Transport Canada (www.tc.gc.ca); at www.tc.gc.ca/eng/policy/report-aca-anre2010-index-2700.htm.
[39] Cambridge Systematics (1994), *Highway Cost & Pricing Study*, Wisconsin DOT (www.dot.state.wi.us).
[40] Mark Delucchi (1998), *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991; Report #7*, Institute of Transportation Studies (http://engineering.ucdavis.edu/).

payments fall short of government expenditures related to motor-vehicle use by between 1¢ and 3.5¢ per vehicle-mile, depending on assumptions concerning the scope of government expenditures included, while European motorists do pay approximately their government costs.[41]

- CE Delft and ECORYS developed a standardized methodology for calculating total infrastructure costs for road, rail and inland waterway, air and marine, which takes into account factors such as infrastructure longevity, discount rates, and allocation of shared costs.[42]

- The Florida DOT's *Transportation Costs* reports summarize the average cost of building, maintaining and operating highways, bridges, traffic control devices, airports, transit systems and bicycle faculties.[43] Table 5.6.4-4 summarizes some of these costs. Note that these estimates exclude planning, land acquisition, intersections, landscaping, and various other costs.

Table 5.6.4-4 **Transportation Facility Costs Per Centerline Mile** (FDOT 2003)

Vehicle Class	2-Lane, Rural	4-Lane, Rural	2-Lane, Urban	4-Lane, Urban
New Construction	$2,172,300	$4,018,600	$2,821,800	$4,765,100
Milling and Resurfacing	$477,800	$686,900	$422,100	$541,200
Routine Annual Maintenance	$21,700	$40,700	$26,300	$58,500
Bike Path, 12-foot width	$467,000	$467,000	$467,000	$467,000
Sidewalks, 5-foot width	$157,000	$157,000	$157,000	$157,000
Traffic Signals	$129,400	$129,400	$113,300	$113,300

- Analysis by the U.S. Bureau of Economic Analysis (Department of Commerce) described in a report by Heintz, Pollin and Garrett-Peltier estimates the total value of U.S. roads at approximately 2.6 trillion, by far the largest category of non-defense public assets.

Table 5.6.4-5 **Non-Defense Public Asset Valuation, 2007**[44]

Asset	Total (billions)	Share
Equipment	$391.1	4.8%
Roads	*$2,634.1*	*32.3%*
Transportation	$532.4	6.5%

41 Mark Delucchi (2007), "Do Motor-Vehicle Users in the US Pay Their Way?," *Transportation Research Part A* (www.elsevier.com), Volume 41, Issue 10, Dec. 2007, pp. 982-1003.

42 Ecorys Transport and Ce Delft (2005), *Infrastructure Expenditures and Costs: Practical Guidelines to Calculate Total Infrastructure Costs for Five Modes of Transport*, CE Delft (www.ce.nl) for the European Commission (www.ec.europa.eu); at http://ec.europa.eu/ten/transport/studies/doc/2005_11_30_guidelines_infrastructure_report_en.pdf

43 FDOT (2003), *2002 Transportation Costs*, Office of Policy Planning, Florida Department of Transportation (www.dot.state.fl.us/planning/policy).

44 James Heintz, Robert Pollin and Heidi Garrett-Peltier (2009), *How Infrastructure Investments Support the U.S. Economy: Employment, Productivity and Growth*, Political Economy Research Institute (www.peri.umass.edu) for the Alliance for American Manufacturing, Table 1.1; at www.americanmanufacturing.org/wordpress/wp-content/uploads/2009/01/peri_aam_finaljan16_new.pdf.

Water	$529.6	6.5%
Sewer	$382.4	4.7%
Power	$241.4	3.0%
Healthcare	$225.9	2.8%
Education	$1,608.6	19.7%
Public Safety	$207.6	2.5%
Conservation and recreation	$450.2	5.5%
Other assets	$953.7	11.7%
Totals	*$8,157.0*	*100.0%*

Roads are the most valuable category of public assets.

- The *Highway Economic Requirements System* developed by the U.S. Federal Highway Administration to evaluate highway improvement needs and benefits, including guidance on roadway impact analysis, and construction costs.[45]

- A study of 258 transportation projects found significant cost underestimates, with greater underestimating for rail compared with highway projects, for tunnels compared with bridges, and for projects in developing countries and Europe compared with U.S. projects.[46]

- Analysis of the 2003 Graz, Austria (238,000 inhabitants) municipal budget found that €60 million was spent in total on automobile facilities and services (road, parking facilities and traffic services) compared with vehicle user fee revenues of €21, a 35% cost recovery rate.[47] These motor vehicle subsidies average €169 annual per capita. About half the automobile expenditures street construction and maintenance. The second highest expenditure was €16.5 million traffic management (traffic signals and signs, parking enforcement, street lighting, and landscaping). The most striking expenditure is €500,000 annual rent for an unpriced parking facility. Similar results were found in the cities of Genève, Switzerland (local subsidies for automobile facilities and services averaged €142 per capita in 2002) and Ferrara, Italy (local subsidies for automobile facilities and services averaged €44 per capita).

- In the city of Milwaukee in 1991, automobile use receives a total subsidy estimated to average $426 per vehicle (road construction and maintenance, 30% of policing costs, street lighting, stormwater management, air pollution and additional land consumption),

[45] FHWA (2002), *Highway Economic Requirements System: Technical Report*, Federal Highway Administration, U.S. Department of Transportation (www.fhwa.dot.gov); at http://isddc.dot.gov/OLPFiles/FHWA/010945.pdf

[46] Bent Flyvbjerg, Mette Skamris Holm and Søren Buhl (2002), "Underestimating Costs In Public Works Projects: Error or Lie?," *Journal of the American Planning Association*, (www.planning.org/japa) Vol. 68, No. 3 Summer, pp. 279-295; at www.planning.org/japa/pdf/JAPAFlyvbjerg.pdf

[47] ICLEI (2005), *Hidden Subsidies for Urban Car Transportation: Public Funds for Private Transport*, European Commission Directorate General for Environment, International Council for Local Environmental Initiatives (www.iclei.org); at www.increase-public-transport.net/fileadmin/user_upload/Procurement/SIPTRAM/Hidden_subsidies_final.pdf.

equivalent to three-quarters of the total city property tax levy.[48] The researcher argues that it is more fair and efficient to charge these costs directly to vehicle owners, which would allow property taxes on a $50,000 house to be reduced by approximately $500. Such as shift would result in-less pollution, less congestion and less sprawl, and a more efficient local transportation system.

- Lee identifies the road system externalities described in the table below. He also recommends charging an additional state road service tax to be consistent with other economic activities, totaling $15.9 billion a year, or about 0.7¢ per vehicle mile.

Table 5.6.4-6 **Estimates of Road System Externalities**[49]

Costs	Billions of Dollars
Construction Expenditures	$42.5
Interest	26.3
Pavement, ROW, and structure maintenance	20.4
Administration and research	6.9
Total roadway expenditures	$96.1
Minus $55 billion road user payments	$96.1 - $55.0 = $41.1
Subsidy per mile (assuming 2,300 billion VMT)	1.8¢

- The Metropolitan Planning Council calculates that Chicago area drivers paid $1,950 in user fees (fuel taxes, registration and licensing, tolls and traffic fines), while $2,109 was spent on roadway facilities in 1993, indicating a 0.3¢ per VMT external cost.[50]

- Mansour-Moysey and Semmens calculate that highway user charges would need to increase about 30% (from 4.0¢ to 5.2¢ per vehicle-mile) to provide a normal 5% return on investment (i.e., for the sake of economic neutrality).[51]

- Morris and DeCicco conclude that U.S. road user fees totaled $76 billion, while roadway expenses totaled $97 billion or more, indicating that road user fees only cover 78% of public road expenses.[52]

- The National Surface Transportation Infrastructure Financing Commission estimates the U.S. highway system requires $134 to $262 billion in annually in investments, or 4.4¢ to

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48 Kenneth Kinney (1991), *Should Property Taxes Subsidize Automobile Usage*, Wisconsin DOT, National Transportation Library, USDOT (http://ntl.bts.gov/), November 1991.

49 Douglass Lee (1995), *Full Cost Pricing of Highways*, USDOT, Volpe National Transportation Systems Center, (www.volpe.dot.gov), January 1995, p. 12.

50 David Urbanczyk and Jeanette Corlett (1995), *The Cost of Driving in the Chicago Metropolitan Region*, Metropolitan Planning Council (www.metroplanning.org), Working Paper No. 2, Feb. 1995.

51 Nadia Mansour-Moysey and John Semmens (2001), Value of Arizona's State Highway System," *Transportation Research 1747*, Transportation Research Board (www.trb.org), pp. 3-11.

52 Hugh Morris and John DeCicco (1997), "Extent to Which User Fees Cover Road Expenditures in the United States," *Transportation Research Record 1576*, Transportation Research Board (www.trb.org), pp. 56-62.

8.7¢ per vehicle mile, depending on the cost estimate and service quality target used.[53] Vehicle users fees would need to increase 75% and 245% to provide these funds.

- Jung Eun Oh, Samuel Labi and Kumares C. Sinha use economic theory and travel demand and highway expenditure data from the State of Indiana as a basis to establish efficient VMT fee rates under various expenditure and funding scenarios.[54] The authors have found that a VMT fee of 2.9¢ per mile, plus federal aid, would cover current expenditures for state-administered highways in the absence of other revenue sources, and a fee of 2.2¢ per mile would be sufficient if revenue from vehicle registration was maintained. They also establishes equitable fee structures that ensure self-finance of each facility class, as well as an alternative uniform-rate fee structure that entails cross-subsidy across facility classes. For the latter, it was found that the urban highway system would subsidize the rural system, the rural Interstate system would subsidize the rural non-Interstate system, and the urban non-Interstate system would subsidize the urban Interstate system. Different VMT fee structures could be established on the basis of desired levels of equity across different facility or user classes.

- Puentes and Prince find that fuel taxes fund only about 35% of total roadway expenditures, and total vehicle user fees (fuel taxes, vehicle taxes and fees, and road tolls) fund about 59%.[55] The portion of roadway funding from fuel taxes is declining because taxes have not increased with inflation or vehicle fuel efficiency.

- Ryan and Stinson found that in the Twin Cities (Minneapolis and St. Paul) area, $240 million in fuel taxes, $245 million in vehicle registration fees, $242 million in local property taxes, and $105 million in state general taxes are spent on roads.[56] An average household pays $500 in annual taxes to fund for roads, of which only one-third are directly related to how much a household drives. They examine the impacts of alternative road funding options (higher fuel taxes and a mileage-based tax) on various households. They suggest that more use-based road funding could help reduce urban sprawl.

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[53] NSTIFC (2009), *Paying Our Way: A New Framework Transportation Finance*, National Surface Transportation Infrastructure Financing Commission (http://financecommission.dot.gov).

[54] Jung Eun Oh, Samuel Labi and Kumares C. Sinha (2007), "Implementation and Evaluation of Self-Financing Highway Pricing Schemes," *Transportation Research Record 1996*, TRB (www.trb.org), pp. 25-33.

[55] Robert Puentes and Ryan Prince (2003), *Fueling Transportation Finance: A Primer on the Gas Tax*, Center on Urban and Metropolitan Policy, Brookings Institute (www.brookings.edu); at www.brookings.edu/reports/2003/03transportation_puentes.aspx

[56] Barry Ryan and Thomas F. Stinson (2002), *Road Finance Alternatives: An Analysis of Metro-Area Road Taxes*, Center for Transportation Studies, University of Minnesota (www.cts.umn.edu).

- The Canadian roadway system was estimated to have a replacement value of $195 billion in 1993, an annualized value of about $15 billion in 2001 dollars, averaging about 3¢ per vehicle kilometre.[57]

- TeleCommUnity (2002) estimated that U.S. roadway rights-of-way total 625,517,587,200 square feet or 22,437 square miles, with a value of $3,565 billion, or up to $10.9 trillion using a *comparable transaction valuation* methodology.[58] Using U.S. federal data they estimate that the entire roadway system has a present value of $4,676 billion, of which $3,565 billion (76%) is land value and $1,110 billion (24%) is for improvements.

- van Essen, et al. discuss various infrastructure cost allocation methods, and provide estimates of roadway costs for various vehicles and conditions.[59] Vermeulen, et al (2004) apply this method to estimate the Netherlands infrastructure, as summarized below.

Table 5.6.4-7 **Variable Road Infrastructure Operating Costs** (€ct/vkm)[60]

Vehicle Category	Urban	Rural	Total
Freight Vehicles			
HGV, single unit < 12 t	24.16	0.76	10.12
HGV, single unit > 12 t	5.39	5.17	5.21
HGV, tr/tr comb. > 12 t	7.71	12.87	12.35
Passenger transport			
Car	0.50	0.16	0.24
Bus	7.99	7.78	7.93
Coach	7.43	10.91	10.21
Motorcycle	0.38	0.31	0.34
Moped, scooter	0.32	1.74	0.37
Light Goods Vehicle (truck or van)	1.93	0.18	1.05

This table indicates in Euro Cents per Vehicle-Kilometer the roadway costs of various vehicle types.

- Accommodating an additional daily peak-period vehicle trip in Liberty, MO (a suburb of Kansas City) is calculated to cost $2,353 in local roadway capacity expansion expenses.[61] This represents an annualized value of about $125 per year or about 31¢ per additional peak-period trip (assuming 400 peak-period trips per year). This article describes the methodology that can be used to calculate these incremental capacity costs.

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57 Stephanie Richardson (1996), *Valuation of the Canadian Road and Highway System*, Transport Canada (www.tc.gc.ca),TP12794E.

58 TeleCommUnity (2002), *Valuation Of The Public Rights-Of-Way Asset*, TeleCommUnity (www.telecommunityalliance.org); at www.telecommunityalliance.org/images/valuation2002.pdf.

59 van Essen, et al (2004), *Marginal Costs of Infrastructure Use – Towards a Simplified Approach*, CE Delft; results published in Vermeulen, et al (2004), *The Price of Transport: Overview of the Social Costs of Transport*, CE Delft (www.ce.nl); at www.ce.nl/eng/pdf/04_4850_40.pdf.

60 Vermeulen, et al (2004), *The Price of Transport: Overview of the Social Costs of Transport*, CE Delft (www.ce.nl); at www.ce.nl/eng/pdf/04_4850_40.pdf.

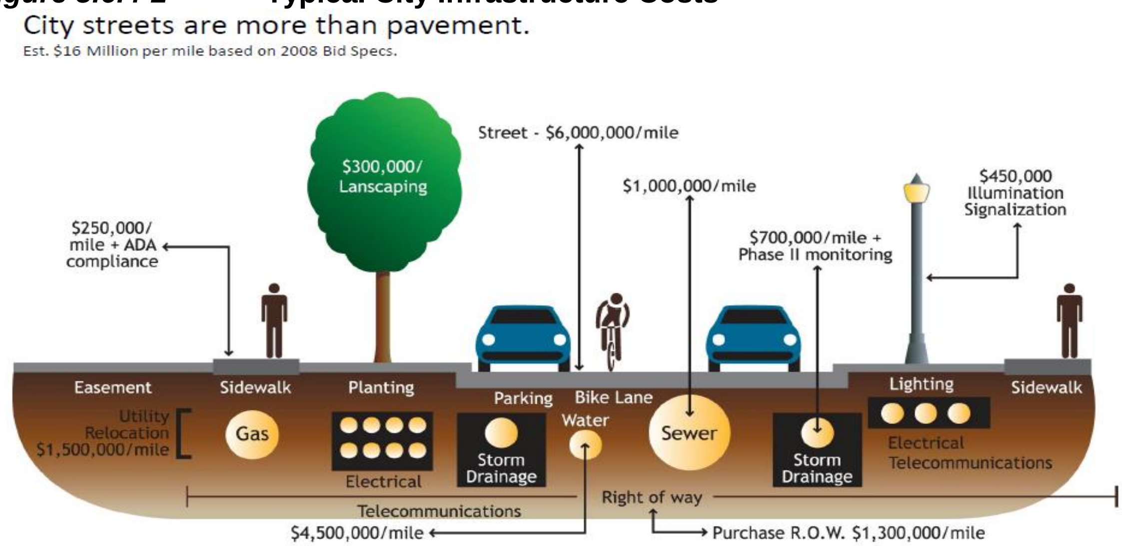
61 Michael R. Wahlstedt (1999), *Development of Trip Costs for an "Impact Fee" Based Excise Tax*, 1999 Annual Meeting Compendium, Institute of Transportation Engineers (www.ite.org); at http://www.ite.org/membersonly/digital_library/aha99a43.pdf.

- A University of Wisconsin-Madison study found that between 2004 and 2008, total (local, state and federal) expenditures on roads in Wisconsin averaged $4.24 billion annually, of which $2.50 billion came road user fees, $1.74 billion from general taxes (primarily property and sales taxes) and $600 million was borrowed, indicating that 41% to 55% of road funding (depending on how borrowing is repaid) is from non-users.[62] An average household pays $779 in general taxes to help finance roads, compared with $50 in road user fees devoted to public transit and $34 devoted to other investments.

- A Washington State Department of Transportation study surveyed total development costs for various highways and bridges.[63] Costs range from $1 million (for rural highway widening) to $188 million per lane-mile (for Boston's Big Dig).

- The Washington State Department of Transportation report, *Complete Streets and Main Street Highways: Case Study Resource* provides typical costs for various roadway design features, including sidewalks, bike lanes and lighting, as illustrated in Figure 5.6.4-2.[64]

Figure 5.6.4-2 **Typical City Infrastructure Costs**[65]



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[62] SSTI (2011), *Who Pays for Roads in Wisconsin?* State Smart Transportation Initiative, University of Wisconsin-Madison for 1000 Friends of Wisconsin (www.ssti.org); at http://ssti.us/wp/wp-content/uploads/2011/10/WI_Road%20costs%20report.pdf.

[63] WSDOT (2005), *Highway Construction Costs: Are WSDOT's Highway Construction Costs in Line with National Experience?*, Washington State Department of Transportation (www.wsdot.wa.gov); at www.wsdot.wa.gov/biz/construction/CostIndex/CostIndexPdf/HighwayConstructionCosts2005.pdf

[64] WSDOT (2011), *Washington's Complete Streets and Main Street Highways: Case Study Resource*, Community Planning and Development, Washington State Department of Transportation (www.wsdot.wa.gov/LocalPrograms/Planning) at www.wsdot.wa.gov/NR/rdonlyres/A49BBBE7-16BC-4ACE-AF2B-3C14066674C9/0/CompleteStreets_110811.pdf.

[65] www.wsdot.wa.gov/NR/rdonlyres/68A7578E-F9EA-4228-AC4A-CC5776245675/0/AWCCompleteStreets.pdf

Goods Movement

- Forkenbrock estimates that large intercity trucks cost an average of 0.25¢ per ton-mile of freight shipped in uncompensated roadway costs.[66]

- Lenzi and Casavant estimate the roadway damage costs of trucks to range from 1¢ to 6¢ per ton-mile on state highways, with an average of 5¢, and 2-9¢ per ton-mile on county roads, with an average of 7.5¢.[67] They also estimate the roadway damage costs of overloaded trucks to range from 8¢ to $2.50 per ton-mile, depending on weight.[68]

- Trucks impose marginal infrastructure costs averaging 67¢ Canadian per tonne kilometer (82¢ U.S. per ton-mile).[69] Although heavy trucks make up only about 9% of Canadian vehicle traffic they account for about 25% of roadway costs.

- A study for the New Zealand Transportation Agency found that highway users pay only 40% of total roadway infrastructure costs, representing a $1.5 billion dollar annual subsidy.[70] This results from different ownership models for different transport infrastructure. Ports are largely operated commercially, providing a financial return on economic investments (capital and land). The rail network is state owned and receives an explicit $90 million annual subsidy to cover operating costs. In contrast, the highway network is estimated to be worth $20 billion, but user fees provide no return on capital investments. This makes highway travel in general and truck shipping in particularly relatively cheaper than its competitors.

- The PaveSim computer program developed at the University of Iowa calculates the pavement wear for various types of vehicles under various road conditions.[71]

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[66] 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., pp. 505-526.

[67] Kenneth Casavant and Jerry Lenzi (1989), "Rail Line Abandonment and Public Acquisition Impacts on Economic Development," *Transportation Research Record 1274*, TRB (www.trb.org), pp. 241-251.

[68] Kenneth Casavant and Jerry Lenzi (1993), *Fee and Fine Structure for Overloaded Trucks in Washington*, Transportation Quarterly (www.enotrans.com/Newsmain.htm), Vol. 47, No. 2, April, pp. 281-294.

[69] Transport Concepts (1994), *External Costs of Truck and Train*, Transport Concepts (Ottawa), p.26.

[70] Rockpoint Corporate Finance (2009), Coastal Shipping and Modal Freight Choice, New Zealand Transport Agency (www.nzta.govt.nz); at www.rockpoint.co.nz/publications/Rockpoint%20Coastal%20Shipping.pdf.

[71] M. Asghar Bhatti, Baizhong Lin, Paul Taylor and Leslie Hart (1997), *PAVESIM: Simulation of Pavement Damage Due to Heavy Vehicles*, University of Iowa Public Policy Center (http://ppc.uiowa.edu/dnn4/).

Cycling and Pedestrians

- *Bicyclepedia* (www.bicyclinginfo.org/bikecost) provides information on bicycle facility costs, including typical construction costs for shared use paths, bike lanes, intersection improvements and support facilities.

- *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners, and the General Public*, and the report, *Guidelines for Analysis of Investments in Bicycle Facilities*, provide information on the costs of facilities such as paths, bike lanes, intersection improvements and bicycle parking. The table below summarizes some of these costs, although more specific cost data should be used when available.

Table 5.6.4-8 **Typical Facility Costs**[72, 73]

Measure	Typical Costs (2012 U.S. Dollars)
Separated mulit-use paths	$536,664 to $4,293,320 per mile
Bike lanes	$10,000-50,000 per mile to modify existing roadway (no new construction)
Bicycle parking	$100-500 per bicycle for racks, and $2,000 per locker
Center medians	$150-200 per linear foot
Curb bulbs	$10,000-20,000 per bulb
Marked crosswalk	$100-300 for painted crosswalks, and $3,000 for patterned concrete.
Path (5-foot asphalt)	$30-40 per linear foot
Path (12-foot concrete)	$80-120 per linear foot
Pedestrian refuge island	$6,000-9,000, depending on materials and conditions.
Sidewalks (5-foot width)	$20-50 per linear foot
Speed humps	$2,000 per hump
Traffic signals	$15,000-60,000 for a new signal
Traffic signs	$75-100 per sign.
Traffic circles	$4,000 for landscaped circle on asphalt street and $6,000 on concrete street.

This table summarizes examples of active transport facility costs. Of course, costs may differ significantly from these values depending on specific conditions.

- The *Pedestrian Facilities Users Guide* provides information on typical costs for pedestrian and bike facilities, including sidewalks, paths, crosswalks, traffic calming features such as speed humps and traffic circles, streetscaping, roadway and intersection redesigns, street furniture, and improved traffic law enforcement, as summarized below.

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[72] Max A. Bushell, Bryan W. Poole, Charles V. Zegeer and Daniel A. Rodriguez (2013), *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners, and the General Public*, Pedestrian and Bicycle Information Center (www.walkinginfo.org), Federal Highway Administration; at www.walkinginfo.org/download/PedBikeCosts.pdf.

[73] Kevin J. Krizek, et al. (2006), *Guidelines for Analysis of Investments in Bicycle Facilities*, NCHRP Report 552, TRB (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf.

Table 5.6.4-9 **Typical Nonmotorized Facility Costs**[74]

Measure	Typical Costs
Asphalt walkway	$30-40 per linear foot for 5-foot wide walkway.
Curb ramps	$1,500 per ramp.
Bike lanes	$10,000-50,000 per mile to modify existing roadway (no new construction).
Chokers	$7,000 for landscaped choker on asphalt street, $13,000 on concrete street.
Curb bulbs	$10,000-20,000 per bulb.
Traffic circles	$4,000 for landscaped circle on asphalt street, $6,000 on concrete street.
Chicanes	$8,000 for landscaped chicanes on asphalt streets, $14,000 on concrete streets.
Street closures	$6,500 for landscaped partial closure, $30,000-100,000 for full closure.
Marked crosswalk	$100-300 for painted crosswalks, $3,000 for patterned concrete.
Pedestrian refuge island	$6,000-9,000, depending on materials and conditions.
Center medians	$15,000-20,000 per 100 feet.
Traffic signals	$15,000-60,000 for a new signal.
Raised intersection	$70,000+ per intersection
Traffic signs	$75-100 per sign.
Speed humps	$2,000 per hump
Bike parking	$50-150 per bike for racks and $100-500 per bike for lockers

- Dutch cities typically spend between €10 and €25 annually per capita on cycling facilities, which is considered high and results in high rates of cycling activity.[75]
- Many people assume incorrectly that pedestrians and cyclists pay less than their fair share of roadway costs because they do not pay fuel taxes or vehicle registration fees dedicated to highway funding. Local roads (the roads used most for walking and cycling) are mainly funded through general taxes that residents pay regardless of their travel patterns. Less than 10% of local road funding originates from vehicle user fees in the U.S. Local road funding from general taxes averaged about 2.2¢ per motor vehicle mile of travel on local roads. As a result, people who rely on non-motorized modes and drive less than average tend to subsidize other residents who drive more than average.[76]

[74] Charles Zeeger, et al (2002), *Pedestrian Facilities Users Guide: Providing Safety and Mobility*, Pedestrian and Bicycle Information Center (www.walkinginfo.org), Highway Safety Research Center, Federal Highway Administration, Publication FHWA-RD-01-102; at http://drusilla.hsrc.unc.edu/cms/downloads/PedFacility_UserGuide2002.pdf.
[75] Fietsberaad (2008), *Cycling in the Netherlands*, Ministry of Transport, Public Works and Water Management (www.verkeerenwaterstaat.nl/english/); at www.fietsberaad.nl/library/repository/bestanden/Cycling%20in%20the%20Netherlands%20VenW.pdf.
[76] Todd Litman (2002), *Whose Roads? Defining Bicyclists' and Pedestrians' Right to Use Public Roadways*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/whoserd.pdf.

5.6.5 Variability

Road costs vary greatly depending on vehicle type, travel conditions, location, and perspective.

5.6.6 Equity and Efficiency Issues

Roadway costs are partly internalized through special user fees, but there are often additional external costs. In the U.S. and Canada, most major highway costs can be considered internalized through user fees, but most local roadway costs can be considered external. Non-drivers tend to subsidize drivers through local road budgets. To the degree that road user fees do not accurately reflect the roadway costs imposed by individual vehicles, they can be considered inequitable and inefficient.

5.6.7 Conclusions

Several studies indicate that roadway expenditures not funded through vehicle user fees averaged 1-4¢ per vehicle-mile even before recent construction cost increases. Although a minimal road system is needed for basic access, most current road expenditures can be attributed to specific vehicle use. This understates total roadway cost because it includes no return-on-investment charge (past capital expenditures are treated as sunk costs), and ignores deferred expenditures needed to maintain current performance. Table 5.6.7-1 shows estimated costs by vehicle type, based on various studies described above.

Table 5.6.7-1 **Road Costs Not Funded by User Fees** (2007 Dollars per Vehicle-Mile)

Mode	Estimated External Costs
Automobiles	0.021
Motorcycles	0.011
Pickups and vans	0.027
Buses	0.038

Urban road costs tend to be higher than rural costs per vehicle mile, so urban driving costs are increased and rural costs decreased by 25%. Since electric vehicles pay no fuel taxes, their road costs are all external. Rideshare passengers are considered to impose no additional roadway costs. Since public transit buses are often exempt from some fuel taxes their total cost is used, but this would not apply where such exemptions do not exist. A trolley that travels on tracks does not impose road wear costs, but comparable public costs are required to maintain rails and right-of-way.

A minor portion (perhaps 3-5%) of transportation budgets are devoted to sidewalks, bike lanes and other special facilities for non-motorized travel, but these are needed due to the risks and discomfort that motor vehicle traffic imposes on nonmotorized travel; areas with little or no motor vehicle traffic often have no sidewalks and cyclists and pedestrians use the street. Bicycling and walking cause virtually no pavement wear and require a relatively small amount of road space, so their cost is estimated to be 5% of an automobile. Telework imposes no road facility costs.

Estimate **Road Facility External Costs (2007 U.S. Dollars per Vehicle Mile)**

Vehicle Class	Urban Peak	Urban Off-Peak	Rural	Average
Average Car	0.026	0.026	0.016	0.021
Compact Car	0.026	0.026	0.016	0.021
Electric Car	0.064	0.064	0.038	0.051
Van/Light Truck	0.035	0.035	0.021	0.028
Rideshare Passenger	0.000	0.000	0.000	0.000
Diesel Bus	0.048	0.048	0.029	0.038
Electric Bus/Trolley	0.048	0.048	0.029	0.038
Motorcycle	0.014	0.014	0.008	0.011
Bicycle	0.002	0.002	0.001	0.002
Walk	0.002	0.002	0.001	0.002
Telework	0.000	0.000	0.000	0.000

Automobile Cost Range

Minimum and Maximum values based on US estimates cited above.

Minimum	Maximum
$0.01	$0.04

5.6.8 Information Resources

Information sources on roadway costing are described below.

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ABW (2010), *Bicycling and Walking in the U.S.: 2010 Benchmarking Report*, Alliance for Biking & Walking, (www.peoplepoweredmovement.org); at www.peoplepoweredmovement.org/site/index.php/site/memberservices/C529.

Mohammed Alam, Darren Timothy and Stephen Sissel (2005), "New Capital Cost Table for Highway Investment Economic Analysis," *Transportation Research Record 1932*, TRB (www.trb.org), pp. 33-42; summary at http://trrjournalonline.trb.org/doi/abs/10.3141/1932-05.

Stuart Anderson, Keith Molenaar and Cliff Schexnayder (2006), *Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction*, NCHRP Report 574, TRB (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_574.pdf.

Applied Research Associates (2007), *Estimation Of Road Cost Allocation Between Light Vehicles And Heavy Vehicles In Canada*, Transport Canada (www.tc.gc.ca); at www.tc.gc.ca/pol/en/Report/FullCostInvestigation/Road/r006/r006.pdf.

ASCE (2001), *Guide to Transportation Benefit-Cost Analysis*, American Society of Civil Engineers (www.asce.org); at http://ceenve.calpoly.edu/sullivan/cutep/cutep_bc_outline_main.htm.

ASSET (www.asset-eu.org) is a European Union project to develop practical tools for balancing the protection of environmentally sensitive areas with the provision of efficient transport systems.

Patrick Balducci and Joseph Stowers (2008), *State Highway Cost Allocation Studies: A Synthesis of Highway Practice*, NCHRP Synthesis 378; at http://itd.idaho.gov/taskforce/resources/nchrp_syn_378.pdf.

BEA (2004), *Current-Cost Net Stock of Government Fixed Assets: Table 7.1B.*, Bureau of Economic Analysis (www.bea.gov); at www.bea.gov/bea/dn/FA2004/SelectTable.asp.

Bicyclepedia (www.bicyclinginfo.org/bikecost) is a free bicycle facility benefit/cost analysis tool provided by the University of North Carolina Highway Safety Research Center (www.hsrc.unc.edu).

Franziska Borer Blindenbacher (2005), *Study of Methods of Road Capital Cost Estimation and Allocation by Class of User in Austria, Germany and Switzerland*, Transport Canada (www.tc.gc.ca); at www.tc.gc.ca/policy/report/aca/fullcostinvestigation/road/tp14494/tp14494.htm.

Booz Allen Hamilton (2005), *Surface Transport Costs and Charges Study*, Ministry of Transportation New Zealand (www.transport.govt.nz).

BTS, *Government Transportation Financial Statistics* (www.bts.gov); at www.bts.gov/programs/government_transportation_financial_statistics is a searchable database that provides access to federal, state, and local transport revenues and expenditures.

Max A. Bushell, Bryan W. Poole, Charles V. Zegeer and Daniel A. Rodriguez (2013), *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners, and the General Public*, Pedestrian and Bicycle Information Center (www.walkinginfo.org), Federal Highway Administration; at www.walkinginfo.org/download/PedBikeCosts.pdf.

Cambridge Systematics (2008), *The Highway Construction Equity Gap*, Texas Department of Transportation (www.keeptexasmoving.com).

Cambridge Systematics (2011), *Determining Highway Maintenance Costs*, NCHRP Report 688, Transportation Research Board (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_688.pdf.

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Ecorys Transport and Ce Delft (2005), *Infrastructure Expenditures and Costs: Practical Guidelines to Calculate Total Infrastructure Costs for Five Modes of Transport*, CE Delft (www.ce.nl) for the European Commission (www.ec.europa.eu); at http://ec.europa.eu/ten/transport/documentation/doc/2005_11_30_guidelines_infrastructure_report_en.pdf.

FDOT (2003), *2002 Transportation Costs*, Policy Planning, Florida Department of Transportation (www.dot.state.fl.us/planning/policy); at www.dot.state.fl.us/planning/policy/costs/default.asp.

FHAA, *Truck Pavement Interaction Research*, FHWA; at www.tfhrc.gov/pavement/truck/tech.htm.

FHWA (annual reports), *Highway Statistics*, FHWA, USDOT (www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.cfm).

FHWA (1997 and 2000), *1997 Federal Highway Cost Allocation Study Final Report*, Federal Highway Administration, (www.fhwa.dot.gov); at www.fhwa.dot.gov/policy/hcas/summary/index.htm.

FHWA (2002), *Highway Economic Requirements System: Technical Report*, Federal Highway Administration, USDOT (www.fhwa.dot.gov); at http://isddc.dot.gov/OLPFiles/FHWA/010945.pdf.

FHWA and FTA (2006), *Status of the Nation’s Highways, Bridges, and Transit: Conditions & Performance*, NCHRP, TRB (www.trb.org); at www.fhwa.dot.gov/policy/2006cpr/index.htm.

GAO (2009), *Cost Estimating and Assessment Guide Best Practices for Developing and Managing Capital Program Costs*, United States Government Accountability Office (www.gao.gov); at www.gao.gov/new.items/d093sp.pdf.

Greenroads (www.greenroads.us) describes a proposed standard for quantifying sustainable practices associated with the design and construction of roads.

Ronald Hirshhorn (2003), *Concepts And Practical Values Of Land Costs And Capital Charges For A "Full-Cost Accounting" Of Transport Infrastructure In Canada*, Transport Canada Policy Group (www.tc.gc.ca/pol/en/aca/fci/transmodal/menu.htm); at www.tc.gc.ca/pol/en/Report/FullCostInvestigation/Transmodal/tp14484/tp14484.pdf.

Joseph Henchman (2014), *Gasoline Taxes and User Fees Pay for Only Half of State & Local Road Spending*, Tax Foundation (http://taxfoundation.org); at http://taxfoundation.org/sites/taxfoundation.org/files/docs/ff410.pdf.

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