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Sightline Research Backgrounder

Increases in greenhouse-gas emissions from highway-widening projects

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SUMMARY

Road-building proponents often suggest that adding lanes to a highway will reduce greenhouse gas emissions. By easing congestion, they argue, new lanes will reduce the amount of fuel that vehicles waste in stop-and-go traffic, leading to lower releases of climate-warming gases from cars and trucks.

Over the short term—perhaps 5 to 10 years after new lanes are opened to traffic—this argument may hold some slim merit. But considering the increased emissions from highway construction and additional vehicle travel, adding one mile of new highway lane will increase CO_2 emissions by more than 100,000 tons over 50 years.

Carbon dioxide emissions from building one lane-mile of urban highway, over 50 years	
Construction, building materials, and maintenance	3,500 tons
Net congestion relief	-7,000 tons
Additional vehicle travel on the facility	90,000 tons
Induced vehicle travel off the facility	30,000–100,000 tons
TOTAL	116,500-186,500 tons

At current rates of emissions, 100,000 tons of CO_2 equals the 50-year climate footprint of about 100 typical US residents.

Because future traffic volumes, vehicle technologies, and land use patterns are inherently uncertain, these estimates should be taken as rough approximations. Yet under almost any set of plausible assumptions, widening a highway in a congested urban area will substantially increase long-term greenhouse gas emissions.

ANALYSIS AND DISCUSSION

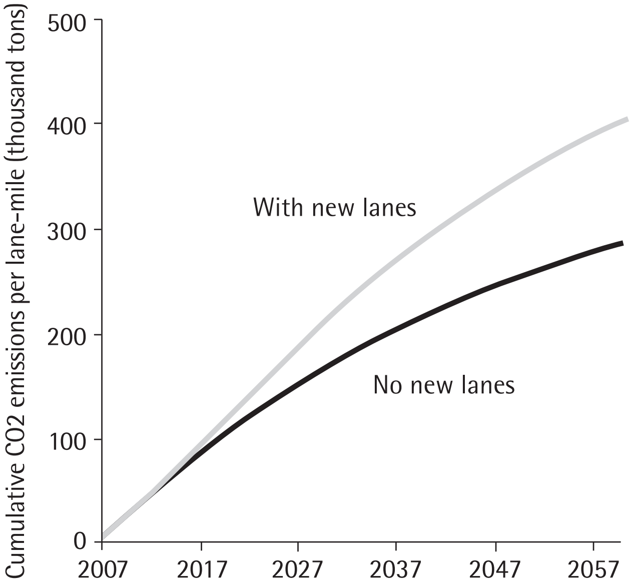
To estimate changes in vehicle emissions resulting from highway lane expansion, Sightline developed a spreadsheet model covering 50 years of highway-related CO_2 emissions. Using this model, Sightline developed a mid-point estimate for highway CO_2 emissions per lane mile, based on a plausible range of possible future travel characteristics. Sightline's model predicts changes in CO_2 emissions as follows (see Method Notes for details of our assumptions and analysis):

1. THE HIGHWAY ITSELF: 3,500 tons of CO_2 from road construction and maintenance

Two recent international studies of the life-cycle energy costs of highway construction have estimated that, after accounting for the manufacturing of concrete, steel, and other energy-intensive construction materials, as well as fuel consumed by construction equipment, building a lane-mile of roadway releases between 1,400 and 2,300 tons of CO_2. In addition, long-term maintenance and road reconstruction activities release between 3,100 and 5,200 tons of CO_2 emissions.

Based on these figures, and a more conservative estimate of annual maintenance-related emissions than these studies assume, Sightline estimates that constructing 1 lane-mile of highway and maintaining it for 50 years releases roughly 3,500 tons of CO_2.

After new lanes are completed, emissions from additional traffic quickly overwhelm short-term congestion relief.



2. NET CONGESTION RELIEF: 7,000 fewer tons of emissions from efficiency gains.

Highway construction and maintenance projects can create substantial congestion and traffic delays, reducing the fuel efficiency of the vehicles on the road.[1] However, for these estimates, Sightline assumed that construction projects would cause fairly minor, intermittent delays, and that traffic volumes would not decrease during construction. On net, we estimate that congestion resulting from construction and maintenance delays would increase vehicle-related CO_2 emissions modestly, by roughly 500 tons.

Sightline assumes that rush hour traffic will flow more freely after new lanes are opened, and that congestion relief will raise the effective fuel efficiency of vehicles on the roadway. However, consistent with academic findings and real-world experience, we also assume that new highway capacity in a metropolitan area will gradually be filled by new trips, and that congestion and stop-and-go driving will gradually increase to approximately the same level experienced prior to the highway expansion.[2] Over the course of 50 years, CO_2 emissions reductions related to congestion relief may total some 7,500 tons, compared with a "baseline" highway that is not widened. The large majority of these emissions reductions occur within the first decade in which a new lane is open to traffic.

On net, then, we expect that changes in congestion associated with highway expansion (including both congestion created by construction and maintenance, and congestion relieved after construction) will reduce emissions by about 7,000 tons.

3. NEW TRAFFIC: 90,000 tons of emissions from additional travel on the highway.

It is well documented that highway expansion can result in an increase in the number of vehicle trips on a roadway, particularly in congested urban areas. Indeed, accommodating additional trips is typically the point of adding new lanes to a highway. Still, the speed at which additional traffic floods new lanes often comes as a surprise. One recent California study estimated that more than roughly 90 percent of new lane capacity in congested urban areas is filled within five years after a project is completed. Other studies have found similar "induced traffic" effects from adding lanes to congested roads.

However, not all of the additional traffic on new lanes represents genuinely new travel. Very shortly after a new road or lane opens, for example, some trips that had been taken on other streets and roads shift to the new facility. To account for this effect, Sightline assumes that for the two years after new lanes are opened, none of the additional trips taken on a new facility are genuinely new, but were simply rerouted from nearby roads onto the new facility.

The greenhouse gas impacts of future travel will be affected by changes in vehicle technology and fuel efficiency. Yet even assuming that average vehicle fuel economy improves by 2.5 percent a year (an optimistic assumption, given that the average fuel economy of passenger vehicles has stagnated for decades), Sightline estimates that new vehicle travel on each lane-mile of new highway will release 83,000 tons of CO_2 over the next 50 years. Adding in energy associated with vehicle manufacture and maintenance, this total rises to approximately 90,000 additional tons of CO_2 per lane mile associated with new vehicle trips on an expanded facility.[3]

4. INDIRECT FUEL CONSUMPTION: 30,000-100,000 tons of CO_2 from induced travel off the highway itself.

Travel patterns off the expanded highway are the most difficult to project, since they involve the greatest uncertainties.

Cars that travel on a new highway lane will need to travel on other streets and roads to get to and from the highway; this will result in some additional vehicle mileage beyond the driving that takes place on the highway itself. As a conservative value, Sightline estimated that for each 10-mile trip on a highway, the vehicle is driven a total of 1 mile to and from the highway on- and off-ramps.

In addition, adding lanes—particularly on roads leading to low-density suburbs and undeveloped land on the urban fringe—tends to accelerate low-density sprawling development. Many studies have linked lower-density land use patterns with increased driving. In a sprawling suburb, virtually every trip must be taken by car, and everyday trips can require many miles of travel. In contrast, residents of more compact suburbs and urban neighborhoods typically drive less, and can walk or use transit for many trips, which reduces the carbon emissions from their daily transportation. Accordingly, low-density development is associated with increased vehicle fuel consumption.[4]

Sightline estimates that if as little as one-tenth of new highway trips represent a net shift to lower-density land use patterns (i.e., new sprawling suburban development with modestly higher per-household driving than in compact suburbs), then greenhouse gas emissions from additional off-facility driving could rival or exceed the increases from driving on the facility itself. Regardless of the precise figures, the impacts of off-facility driving enabled by highway expansion are likely to be significant, long-lasting, and far larger than the modest reductions in emissions resulting from congestion relief.

CONCLUSIONS

Our estimates suggest that, over the course of five decades, adding new highway lanes will lead to substantial increases in vehicle travel and CO_2 emissions from cars and trucks. Claims about fuel savings from congestion relief may hold slim merit over horizons of a decade or less. But over the long term, new traffic will fill the added road space, leading to long-term increases in vehicle emissions totaling tens of thousands of tons per lane-mile.

Future refinements in Sightline's emissions model, and the data that it relies on, may affect the specifics of these estimates. Yet under most plausible assumptions for future travel patterns and vehicle efficiencies, Sightline's model predicts that added emissions from new traffic will overwhelm the modest greenhouse gas reductions from congestion relief.

METHOD NOTES

To estimate changes in vehicle emissions resulting from highway lane expansion, Sightline developed a spreadsheet model covering 50 years of highway-related CO_2 emissions. This model relied on the following assumptions and inputs:

Number of lanes: Sightline's model considers an existing metro-area highway with two lanes in each direction that is widened to three lanes in each direction.[5]

Per-mile fuel consumption: Given today's vehicle and fuel technologies, Sightline estimates that the average passenger vehicle creates 1.1 pounds of CO_2 emissions per mile. This covers emissions throughout the "well-to wheels" emissions of the vehicle fuel, including drilling, transporting, and refining petroleum, as well as the end-use consumption of gasoline in passenger vehicles.[6]

- Improvements in vehicle efficiency: Sightline assumes that, over 50 years, average vehicle CO_2 emissions per mile will decline to less than one-third of today's levels, through a combination of improved vehicle efficiency and lower-carbon fuels.[7]
- Congestion-related efficiency losses: When vehicles are operating on a

congested highway, Sightline estimated that emissions per mile increase by about one-third—comparable the difference between "city" and "highway" miles-per-gallon ratings.[8] Note, however, that even for highways that experience rush-hour congestion, fewer than half of all trips take place during peak travel hours.[9]

- Emissions from vehicle manufacturing: Roughly 9 tons of CO_2 are released during the manufacture a passenger vehicle.10 Sightline assumes that today's cars and light trucks average 180,000 miles of travel over their usable life spans,[11] and that vehicle manufacturing emissions will decline in the future by 1 percent per year.
- Emissions from road construction and maintenance: Sightline used recent peer-reviewed studies to estimate CO_2 emissions from road construction and maintenance.[12]
- Traffic volumes: Sightline assumed that daily traffic volumes on existing lanes would start at between 15,000 and 20,000 daily vehicle trips per lane, rising to a steady state somewhere between 18,000 and 24,000 vehicles per lane over time. Once new lanes are open to traffic, Sightline estimated that 10 percent of any remaining highway capacity would be filled with traffic each year.[13]
- Off-highway driving: For every highway trip, vehicles must travel some distance to and from the highway. In addition, new highway construction can promote scattered, low-density residential and commercial development, which in turn requires residents to drive more miles.[14] Because of the high degree of uncertainty for both effects, Sightline makes conservative estimates for off-highway driving. For new trips resulting from increased capacity, Sightline assumes that vehicles travel one-tenth of a mile of off-highway driving for every mile of on-highway driving. Sightline's low-end estimate of emissions from land use effects assumes that only 5 percent of new trips represent new low-density households, and that these households drive 15 percent more than their higher-density counterparts.

Sightline found that the model's outputs were most strongly affected by three inputs: trends in vehicle fuel efficiency; the difference between current vs. maximum traffic per lane; and the rate at which new lanes are filled by new traffic. In addition, assumptions about off-highway driving and land-use impacts strongly affected total emissions. However, these latter factors are the most inherently uncertain, since they are dependent on geographic, regulatory, and economic factors that are outside the scope of this analysis.

To avoid the chance of overestimating the CO_2 impacts of lane expansion, Sightline's estimates are conservative in a number of ways, including:

- Slow rate of induced traffic: Sightline's midpoint estimates are based on the assumption that 10 percent of any remaining road capacity will be filled per year after a new lane opens—meaning that less than half of added lane capacity is filled within 5 years of completion. In contrast, many recent studies have found that as much as 90 percent of new capacity may be filled within 5 years after a new lane is opened.15 Assuming faster rates of induced travel would reduce estimated benefits of congestion relief, while increasing total emissions from generated traffic.

- Low maintenance-related emissions: Sightline assumes a lower total energy consumption from road maintenance and repair than is assumed by several academic studies.
- Assuming no induced travel on parallel roadways: Sightline's model assumes that all new traffic entering a roadway for the first year and half after new lanes are opened represents trips rerouted from nearby routes, rather than genuinely new travel. In addition, Sightline's model assumes that rerouted traffic represents a *permanent* reduction of travel on parallel roadways—an assumption that is inherently conservative, since traffic on parallel roadways is likely to grow as congestion increases on new lanes *(Text updated and corrected June 26, 2008)*.

ENDNOTES

1 For four highway-widening projects analyzed by the Surface Transportation Policy Project in the late 1990s, the "payback" period—the period after which time savings due to added road capacity equaled time lost during road construction—ranged from 2.75 years to infinity. In the latter case, travelers never recouped the time lost to congestion during construction. See STPP, "Road Work Ahead: Is Construction Worth the Wait?" at *http:www.transact.org/report.asp?id=169*.

2 An excellent of the literature on "induced" or "generated" traffic can be found in Todd Litman, "Generated Traffic and Induced Travel: Implications for Transport Planning" at *http://www.vtpi.org/gentraf.pdf*. See especially pages 7 and 8 for estimates of "generated traffic" from highway expansion. Also see page 4 for a discussion of how a congested roadways tend to reach an equilibrium daily traffic volume.

3 Carbon intensities for future vehicle and fuel technologies are impossible to predict, since they depend on regulatory, economic, technological, and geological factors that are outside the scope of this report. Yet even if effective vehicle fuel economy rises to 100 mpg over 50 years, GHG emissions from new traffic on the lane will still total some 60,000 tons—far more than the relatively modest greenhouse gas benefits from congestion relief.

4 For more on the relationship between urban form and vehicle travel, see:

Frank, Lawrence and Company, Inc. (2005). "Achieving Sustainability Through Healthy Community Design." King County, WA. September 27, 2005.

Golob, Thomas, and David Brownstone (2005). "Impact of Residential Density on Vehicle Usage and Energy Consumption." Institute of Transportation Studies, UC-Irvine. *http://www.its.uci.edu/its/publications/papers/ITS/UCI-ITS-WP-05-1.pdf*

Holtzclaw, John (1998). "Curbing Sprawl to Stop Global Warming," Sierra Club. *http://www.sierraclub.org/sprawl/articles/warming.asp*

Holtzclaw, John (2000). "Smart Growth—As Seen From the Air," Air& Waste Management Association Annual Meeting, June 2000. *http://www.sierraclub.org/sprawl/transportation/holtzclaw-awma.pdf*

Holtzclaw, John, et al (2002). "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Driving; Studies in Chicago, Los Angeles, and San Francisco." Transportation Planning and Technology, March 2002.

Kahn, Matthew. (2000). "The Environmental Impact of Suburbanization." Journal of Policy Management," Vol. 19, No 4, *http://www.environmentalleague.org/Issues/Land/Kahn_2.pdf*

Newman and Kenworthy (1989b). Cities and Automobile Dependence: An International Sourcebook.

Newman and Kenworthy (1999). Sustainability and Cities: Overcoming Automobile Dependence, Washington, DC: Island Press.

U.S. Environmental Protection Agency (2001). "Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality." Development, Community, and Environment Division, January 2001. *http://www.epa.gov/dced/pdf/built.pdf*

5 Note that the end results do not depend heavily on these assumptions. Other configurations of highway expansion lead to virtually identical results.

6 Current average passenger vehicle fuel economy is approximately 21 mpg; see *http://www.epa.gov/otaq/fetrends.htm* and *http://www.washingtonpost.com/wp-dyn/content/graphic/2006/07/18/GR2006071800596.html*. This is likely a conservative estimate of highway vehicle emissions, since it represents only passenger vehicles, while ignoring heavy trucks that emit significantly more CO_2 per mile. Life-cycle CO2 emissions per gallon of gas estimated at 25.6 pounds; derived from *http://www.environmentaldefense.org/documents/3986_CAautocarbonburden.pd*f, p. 11.

7 It is possible that future vehicle and fuel technologies may achieve even better results. However, given that US vehicle fuel economy has stagnated for roughly two and a half decades, any improvement in the fuel economy of the vehicle fleet is, at this point, purely a matter of speculation. If carbon emissions from vehicle travel fall more slowly than Sightline assumes, then Sightline's analysis may substantially understate eventual carbon emissions resulting from highway expansion.

8 City vs. highway fuel economy derived from data downloaded from the US Department of Energy, at *http://www.fueleconomy.gov/feg/download.shtml*. Note, however, that hybrid gas-electric engines are actually more efficient in stop-and-go city driving than in free-flowing traffic—suggesting that the fuel-conserving benefits

of congestion reduction may fall over time as these technologies are used more widely.

9 In a study of 75 US metropolitan areas, just over 40 percent of vehicle travel in 2000 took place at times when major roadways typically experience congestion, and 25.5 percent of all travel took place under congested conditions. See Anthony Downs, Still Stuck in Traffic: Coping With Peak-Hour Traffic Congestion, Washington, DC, Brookings Institution Press, 2004, p. 16. Similarly, data for the Puget Sound region show that roughly 42 percent of total travel on the region's busiest highways in 2005 took place during peak periods (6 to 9 a.m. and 3 to 7 p.m. inclusive); see *http://depts.washington.edu/hov/2005/WkdyVehVol/2005_WkdyVehVol.pdf*. And data from the US Bureau of transportation statistics suggests that 43 percent of all trips nationwide take place during the morning and afternoon peak periods; see *http://www.bts.gov/publications/journal_of_transportation_and_statistics/volume_06_number_01/html/paper_02/table_02_02.html* and *http://www.bts.gov/publications/highlights_of_the_2001_national_household_travel_survey/html/table_a12.html*. Considering both the increases in per-mile emissions caused by congestion, with , Sightline estimates that peak-hour congestion increases fuel-related CO_2 emissions on a roadway by about 15 percent.

10 Sightline's estimates for the carbon intensity of vehicle manufacture are based on a number of published sources, including:

Argonne National Laboratory, F. Stodolsky et al., "Life-Cycle Energy Savings Potential from Aluminum-Intensive Vehicles," at *http://www.transportation.anl.gov/pdfs/TA/106.pdf*.

Environmental Defense, John DeCicco and Kate Larsen, "Automaker Carbon Burdens in California," 2004, available at *http://www.environmentaldefense.org/documents/3986_CAautocarbonburden.pdf*.

Web page, "Life cycle assessment: Toyota's comprehensive analysis of vehicle CO_2 emissions over the life of the vehicle reveals some surprizes [sic]," Automotive Industries, Feb. 2005, at *http://findarticles.com/p/articles/mi_m3012/is_2_185/ai_n12937459*.

Web page, "Automobiles: Electric vs. Gasoline; Seikei University (Tokyo), 2001" Institute for Lifecycle Environmental Analysis, at *http://ilea.org/lcas/taharaetal2001.html*.

Web page, "Report 5: How Do We Contribute Individually to Global Warming," The Hinkle Charitable Foundation, at *http://www.thehcf.org/emaila5.html*.

Web page, "Car Companies and Climate Change: Measuring the Carbon Intensity of Sales and Profits," World Resources Institute, at *http://earthtrends.wri.org/features/view_feature.php?theme=5&fid=53*.

11 Lifetime mileage per vehicle from National Highway Traffic Safety Administration, "Vehicle Survivability and Travel Mileage Schedules," January 2006, at *http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/Rpts/2006/809952.pdf*. Note that the 180,000 mile per vehicle figure currently applies to light trucks, rather than

cars, which are typically driven just 152,000 over their lifetimes; to be conservative, applied the higher figure applies to all passenger vehicles.

12 Life-cycle road construction and maintenance emissions estimated from:

Graham J. Treloar et al., "Hybrid Life-Cycle Inventory for Road Construction and Use," Journal of Construction Engineering and Management, Vol. 130, No. 1, January/February 2004, pp. 43-49 , (DOI 10.1061/(ASCE)0733-9364(2004)130:1(43)),

Kwangho Park et al., "Quantitative Assessment of Environmental Impacts on Life Cycle of Highways," Journal of Construction Engineering and Management, Vol 129, January/February 2003, pp 25-31, (DOI: 10.1061/(ASCE)0733-9364(2003)129:1(25)).

13 As noted in the above review, recent studies have found that three-quarters or more of new road capacity will be filled after the first few years of operation, particularly in crowded urban areas with significant "latent" demand. One California study estimated that 90 percent of new road capacity will be filled within five years. In this context, the estimates used in Sightline's spreadsheet model (i.e., that 10 percent of additional road capacity will be filled per year after a new lane opens) is fairly conservative. See also note 4.

14 See note 4.

15 See note 2.