# "LET'S CORRECT THE IMAGE OF THE DIESEL AND LET'S GET REAL ABOUT THE NEXT 20 YEARS"

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To appreciate the diesel cycle engine and its future potential, one must first get beyond the traditional image. Societal cost/benefit summaries for the current populations of both gasoline and diesel powered vehicles are given. The benefits in terms of the transportation work performed, and the costs are in terms of the fuel energy consumed plus the emissions of criteria air pollutants, toxins, and greenhouse gases.

Reducing the total societal cost of transportation is an important national need. DOE's OTT understands this and has addressed the problem by helping to set the stage and provide the handwriting on the wall:

The stage is set with the unprecedented industry/government transportation R&D collaborations managed by OAAT and OHVT.

The handwriting on the wall is the new information that these programs have already produced.

In the big picture, the new information from OAAT is simply that the longer range technologies are further out than many thought. From OHVT, it is the recognition that development of advanced HSDI (high speed direct injection) diesel engines for light trucks provides the greatest potential for major reductions in fuel use and $CO_2$ emissions. In this year of the PNGV technology downselect, and DOE's reorganization to better effect real world change, we must make best use of this valuable new information. Best use is simply accepting all the facts and better predictions we now have regarding new technologies, required infra-structures, market demands, future oil price, tax policy, regulations, etc. This collective new, and better informed, view of the future strongly suggests:

1. We can make a significant impact on the social cost of transportation within the next 20 years.

2. The critical enabler will be a much cleaner and user friendly generation of diesel cycle engines.

**HOW BAD ARE DIESEL EMISSIONS ?**

**WHAT ABOUT THE CO2, FUEL EFFICIENCY AND FLASHPOINT ADVANTAGE ?**

**WE NEED A FAIR MEANS OF COMPARISON.**

**WE NEED TO GET CALIBRATED.**

**CAN WE ESTIMATE A TOTAL SOCIETAL COST WITH A LOGICAL COMMON DENOMINATOR ?**

**COST/BENEFIT ANALYSIS ?**

## ON-ROAD VEHICLE EMISSIONS

## DIESEL VS. GASOLINE

Ref.: EPA National Air Pollutant Emission Trends, Oct. 1996, etc.

| | GASOLINE % SHARE | DIESEL % SHARE |
|---|---|---|
| ENERGY USE | | |
| % Trans. Oil Energy | 81 | 19 |
| TRANS WORK (ton-miles) | | |
| **% Trans. Work** | **45** | **55** |
| SMOG, $O_3$ | | |
| % VOC,NMHC, tailpipe+evap. | 95<br>(97) | 5 (x 0.56 POCP **)<br>(3) |
| % $NO_x$ | 73 | 27 |
| TOXINS (known) | | |
| % CO | 98 | 2 |
| % $NH_3$ | 100 | 0 |
| % Benzene, | 97 | 3 |
| % 1,3 Butadiene | (95) | (5)*** |
| % Acetaldehyde | (95) | (5)*** |
| % Formaldehyde | (95) | (5)*** |
| GREENHOUSE GASES | | |
| % $CO_2$ | 81 | 19 |
| % $N_2O$ | 99 | 1 |

* Trans. work = overall average thermal efficiency x fuel energy use

** POCP = photochemical ozone creation potential, R.G. Derwent, Photochemical Ozone Creation Potentials ........., *Atmospheric Environment*, 30(2): 181-199, 1996.

***For lack of data, assumed (as other studies have) that the sourcing of these three toxics is apportioned the same as the VOC's.

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| | GASOLINE VEHICLES %SHARE | DIESEL VEHICLES % SHARE | |
|---|---|---|---|
| **PARTICULATES** ("probable toxins") | NATL | NAT'L | SCAB |
| DIRECT | | | |
| % $PM_{10}$ (exhaust + other*) | 34 | 66 | 62 |
| % $PM_{10}$ (exh.+ other weighted at 1/2 of exh.**) | 29 | 71 | 67 |
| % $PM_{10}$ (exh. + other weighted at 1/2 of exh. & catalyst at 3X direct exh.*3) | 49 | 51 | 46 |
| SECONDARY | | | |
| Inorganic | | | |
| % Nitrate $PM_{10}$ ($NO_x$+$NH_3$) | 73 | 27 | 26 |
| % Sulfate $PM_{10}$ ($SO_x$+$NH_3$) | 74 | 26 | 43 |
| Organic | | | |
| % $PM_{10}$ Org. Aerosols (tailpipe+evap.) | 95 | 5 | 4 |
| Overall weighted*4 secondary $PM_{10}$ | 78 | 22 | 27 |
| TOTAL (contribution weighted*4 for worst areas, 2/3 secondary, 1/3 direct; exh. + other) | 63 | 37 | 39 |
| (2/3 secondary, 1/3 direct, exh. + other weighted at 1/2 exh.) | 62 | 38 | 40 |
| (2/3 secondary, 1/3 direct; exh. + other weighted at 1/2 of exh.; catalyst at 3X direct exh.) | 68 | 32 | 33 |

* other = tire, brake and road dust

** assuming 50% of gasoline vehicle $PM_{10}$ is exhaust & 50% tire, brake and road dust
" 85% " diesel " " " " " 15% " " " " "
" other $PM_{10}$ is 1/2 as harmful as exhaust $PM_{10}$

*3 " PM10 from catalyst equipped gasoline vehicles has 3 times the unit risk of PM10 from non-catalyst equipped gasoline or diesel vehicles. EPA 420-R-93-005

*4 contribution allocation as given in "The Social Cost of the Health Effects of Motor Vehicle Air Pollution", Report # 11, UC Davis, pg. 246.

**TABLE S.1 Estimated Emission Values for 17 U.S. Regions**

| | Emission Value ($/ton, 1989 dollars) | | | | |
|---|---|---|---|---|---|
| Area | $NO_x$ | ROG | $PM_{10}$ | $SO_x$ | CO |
| | Damage-Based | | | | |
| Atlanta | 4,330 | 2,150 | 5,170 | 2,720 | N/A |
| Baltimore | 4,430 | 2,210 | 4,520 | 2,620 | N/A |
| Boston | 4,120 | 2,030 | 5,090 | 2,820 | N/A |
| Chicago | 5,380 | 2,700 | 10,840 | 3,600 | N/A |
| Denver | 2,840 | 1,350 | 3,390 | 2,330 | N/A |
| Houston | 6,890 | 3,540 | 5,190 | 2,910 | N/A |
| Las Vegas | 910 | 320 | 2,450 | N/A[a] | N/A |
| Los Angeles | 9,800 | 5,110 | 17,200 | 3,970 | N/A |
| Milwaukee | 3,890 | 1,930 | 2,960 | 2,210 | N/A |
| New Orleans | 3,880 | 1,910 | 3,600 | 2,471 | N/A |
| New York | 7,130 | 3,650 | 15,130 | 4,030 | N/A |
| Philadelphia | 5,940 | 3,010 | 8,360 | 3,340 | N/A |
| Sacramento | 3,870 | 1,920 | 3,150 | 2,190 | N/A |
| San Diego | 5,510 | 2,800 | 4,800 | 2,600 | N/A |
| San Francisco Area | 3,730 | 1,810 | 5,970 | 2,970 | N/A |
| San Joaquin Valley | 4,490 | 2,240 | 6,550 | 2,610 | N/A |
| Wash., D.C. | 4,900 | 2,450 | 6,260 | 3,070 | N/A |
| | Control-Cost-Based | | | | |
| Atlanta | 9,190 | 8,780 | 3,460 | 6,420 | 2,280 |
| Baltimore | 10,310 | 9,620 | 3,170 | 5,600 | 2,490 |
| Boston | 7,980 | 7,850 | 3,120 | 5,060 | 1,610 |
| Chicago | 7,990 | 8,150 | 4,660 | 9,120 | 2,440 |
| Denver | 6,660 | 6,590 | 2,790 | 4,900 | 2,960 |
| Houston | 17,150 | 15,160 | 2,780 | 3,590 | 2,680 |
| Las Vegas | 5,220 | 5,100 | 4,190 | 11,650 | 2,770 |
| Los Angeles | 21,850 | 19,250 | 6,060 | 13,480 | 4,840 |
| Milwaukee | 11,350 | 10,250 | 2,560 | 4,380 | 1,590 |
| New Orleans | 9,190 | 8,670 | 2,400 | 3,130 | 1,410 |
| New York | 12,340 | 11,720 | 5,390 | 11,090 | 3,910 |
| Philadelphia | 11,360 | 10,730 | 4,040 | 7,330 | 3,160 |
| Sacramento | 11,350 | 10,240 | 2,950 | 5,800 | 3,040 |
| San Diego | 14,110 | 12,630 | 3,460 | 6,640 | 2,740 |
| San Francisco Area | 5,230 | 5,760 | 3,200 | 4,900 | 2,460 |
| San Joaquin Valley | 10,310 | 9,630 | 5,110 | 12,480 | 2,750 |
| Wash., D.C. | 9,190 | 8,910 | 3,340 | 5,320 | 3010 |

[a] N/A = not available.

TABLE 11-A.35. COST OF AIR POLLUTION ATTRIBUTABLE TO A 10% REDUCTION IN MOTOR VEHICLE EMISSIONS, BY EMISSION-POLLUTANT PATHWAY AND HEALTH EFFECT, $/1000 VMT (URBAN U.S. TOTAL 1990) (LOWER BOUN

| Emission | Ambient pollutant | Health effect | LDGVs V | LDGVs V+U | LDGVs V+U+RD | LDGTs V | LDGTs V+U | LDGTs V+U+RD | HDGTs V | HDGTs V+U | HDGTs V+U+RD | Total gasoline vehicles V | Total gasoline vehicles V+U | Total gasoline vehicles V+U+RD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO | CO | mortality | 0.23 | 0.23 | 0.23 | 0.35 | 0.35 | 0.35 | 0.91 | 0.91 | 0.91 | 0.26 | 0.26 | 0.26 |
| | | hospitalization | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.14 | 0.14 | 0.14 | 0.04 | 0.04 | 0.04 |
| | | headaches | 0.24 | 0.24 | 0.24 | 0.37 | 0.37 | 0.37 | 0.96 | 0.96 | 0.96 | 0.27 | 0.27 | 0.27 |
| NOx | NO2 | sore throat | 0.28 | 0.28 | 0.28 | 0.44 | 0.44 | 0.44 | 0.87 | 0.88 | 0.88 | 0.32 | 0.32 | 0.32 |
| | | excess phlegm | 0.12 | 0.13 | 0.13 | 0.19 | 0.20 | 0.20 | 0.38 | 0.39 | 0.39 | 0.14 | 0.14 | 0.14 |
| | | eye irritation | 0.11 | 0.11 | 0.11 | 0.18 | 0.18 | 0.18 | 0.35 | 0.35 | 0.35 | 0.13 | 0.13 | 0.13 |
| NOx, NH3 | nitrate PM10 | mortality | 2.77 | 2.79 | 2.79 | 4.28 | 4.33 | 4.33 | 8.56 | 8.65 | 8.65 | 3.12 | 3.15 | 3.15 |
| | | chronic illness | 0.79 | 0.80 | 0.80 | 1.22 | 1.23 | 1.23 | 2.48 | 2.51 | 2.51 | 0.89 | 0.90 | 0.90 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.14 | 0.14 | 0.14 | 0.21 | 0.21 | 0.21 | 0.42 | 0.43 | 0.43 | 0.15 | 0.16 | 0.16 |
| *Total for NOx and NH3 emissions* | | | 4.22 | 4.26 | 4.26 | 6.51 | 6.59 | 6.59 | 13.08 | 13.21 | 13.21 | 4.75 | 4.80 | 4.80 |
| PM2.5 | PM2.5 | mortality | 0.55 | 0.62 | 0.75 | 1.19 | 1.34 | 1.52 | 3.57 | 3.79 | 4.25 | 0.71 | 0.79 | 0.93 |
| | | chronic illness | 0.16 | 0.18 | 0.21 | 0.35 | 0.39 | 0.44 | 1.03 | 1.09 | 1.21 | 0.21 | 0.23 | 0.27 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.03 | 0.03 | 0.04 | 0.06 | 0.07 | 0.08 | 0.18 | 0.19 | 0.21 | 0.03 | 0.04 | 0.05 |
| | | lung cancer | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.07 | 0.07 | 0.07 | 0.01 | 0.01 | 0.01 |
| Coarse PM10 | coarse PM10 | mortality | 0.18 | 0.20 | 0.84 | 0.32 | 0.36 | 1.29 | 0.92 | 0.97 | 3.36 | 0.21 | 0.24 | 0.96 |
| | | chronic illness | 0.05 | 0.06 | 0.22 | 0.09 | 0.10 | 0.33 | 0.27 | 0.28 | 0.87 | 0.06 | 0.07 | 0.25 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.01 | 0.01 | 0.04 | 0.02 | 0.02 | 0.06 | 0.05 | 0.05 | 0.17 | 0.01 | 0.01 | 0.05 |
| *Total for direct PM10 emissions* | | | 0.99 | 1.11 | 2.11 | 2.05 | 2.30 | 3.74 | 6.08 | 6.45 | 10.13 | 1.25 | 1.40 | 2.51 |
| SOx, NH3 | sulfate PM10 | mortality | 0.82 | 1.35 | 1.35 | 1.33 | 2.46 | 2.46 | 2.21 | 3.94 | 3.94 | 0.93 | 1.59 | 1.59 |
| | | chronic illness | 0.23 | 0.36 | 0.36 | 0.37 | 0.66 | 0.66 | 0.60 | 1.03 | 1.03 | 0.26 | 0.43 | 0.43 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.04 | 0.07 | 0.07 | 0.07 | 0.12 | 0.12 | 0.11 | 0.19 | 0.19 | 0.05 | 0.08 | 0.08 |
| *Total for SOx and NH3 emissions* | | | 1.10 | 1.79 | 1.79 | 1.77 | 3.24 | 3.24 | 2.93 | 5.17 | 5.17 | 1.24 | 2.10 | 2.10 |
| VOCs | organic PM10 | mortality | 0.24 | 0.35 | 0.35 | 0.41 | 0.60 | 0.60 | 1.26 | 1.60 | 1.60 | 0.28 | 0.41 | 0.41 |
| | (SOA) | chronic illness | 0.07 | 0.09 | 0.09 | 0.12 | 0.16 | 0.16 | 0.37 | 0.44 | 0.44 | 0.08 | 0.11 | 0.11 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.06 | 0.08 | 0.08 | 0.01 | 0.02 | 0.02 |
| | acetaldehyde | oral cancer | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | benzene | leukemia | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| | 1,3-butadiene | cancer all sites | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.07 | 0.07 | 0.07 | 0.02 | 0.02 | 0.02 |
| | formaldehyde | oral cancer | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Sub-total for VOC emissions* | | | 0.35 | 0.48 | 0.48 | 0.58 | 0.83 | 0.83 | 1.77 | 2.21 | 2.21 | 0.41 | 0.57 | 0.57 |
| VOCs, NOx | O3 | asthma attacks | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.04 | 0.04 | 0.04 | 0.01 | 0.01 | 0.01 |
| | | lower resp illness | 0.04 | 0.04 | 0.04 | 0.06 | 0.07 | 0.07 | 0.14 | 0.15 | 0.15 | 0.05 | 0.05 | 0.05 |
| | | upper resp illness | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.04 | 0.05 | 0.05 | 0.01 | 0.01 | 0.01 |
| | | eye irritation | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.08 | 0.15 | 0.17 | 0.17 | 0.05 | 0.05 | 0.05 |
| *Subtotal mortality effects* | | | 4.80 | 5.55 | 6.31 | 7.87 | 9.44 | 10.55 | 17.42 | 19.86 | 22.71 | 5.51 | 6.44 | 7.29 |
| *Subtotal cancer effects* | | | 0.03 | 0.03 | 0.03 | 0.06 | 0.06 | 0.06 | 0.15 | 0.15 | 0.15 | 0.04 | 0.04 | 0.04 |
| *Subtotal chronic morbidity effects* | | | 1.31 | 1.50 | 1.69 | 2.15 | 2.55 | 2.82 | 4.75 | 5.36 | 6.06 | 1.51 | 1.74 | 1.95 |
| *Subtotal acute morbidity effects* | | | 1.13 | 1.18 | 1.22 | 1.78 | 1.88 | 1.94 | 3.90 | 4.08 | 4.23 | 1.28 | 1.34 | 1.39 |
| *Subtotal ambient PM10* | | | 6.12 | 7.09 | 8.09 | 10.07 | 12.11 | 13.55 | 22.16 | 25.34 | 29.02 | 7.04 | 8.24 | 9.35 |
| *Subtotal ambient O3* | | | 0.10 | 0.11 | 0.11 | 0.17 | 0.18 | 0.18 | 0.37 | 0.41 | 0.41 | 0.12 | 0.13 | 0.13 |
| *Subtotal ambient NO2* | | | 0.52 | 0.52 | 0.52 | 0.80 | 0.82 | 0.82 | 1.60 | 1.62 | 1.62 | 0.58 | 0.59 | 0.59 |
| *Subtotal ambient CO* | | | 0.51 | 0.51 | 0.51 | 0.78 | 0.78 | 0.78 | 2.01 | 2.01 | 2.01 | 0.57 | 0.57 | 0.57 |
| ***Total all emissions, pollutants, effects*** | | | 7.27 | 8.26 | 9.26 | 11.86 | 13.93 | 15.37 | 26.23 | 29.46 | 33.15 | 8.34 | 9.56 | 10.67 |

| Emission | Ambient pollutant | Health effect | LDDVs V | LDDVs V+U | LDDVs V+U+RD | LDDTs V | LDDTs V+U | LDDTs V+U+RD | HDDVs V | HDDVs V+U | HDDVs V+U+RD | Total diesel vehicles V | Total diesel vehicles V+U | Total diesel vehicles V+U+RD | Total all vehicles V | Total all vehicles V+U | Total all vehicles V+U+RD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO | CO | mortality | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.24 | 0.24 | 0.24 |
| | | hospitalization | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 |
| | | headaches | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.26 | 0.26 | 0.26 |
| NOx | NO2 | sore throat | 0.16 | 0.16 | 0.16 | 0.06 | 0.06 | 0.06 | 1.11 | 1.12 | 1.12 | 0.87 | 0.87 | 0.87 | 0.36 | 0.36 | 0.36 |
| | | excess phlegm | 0.07 | 0.07 | 0.07 | 0.02 | 0.03 | 0.03 | 0.49 | 0.49 | 0.49 | 0.38 | 0.39 | 0.39 | 0.16 | 0.16 | 0.16 |
| | | eye irritation | 0.07 | 0.07 | 0.07 | 0.02 | 0.02 | 0.02 | 0.45 | 0.45 | 0.45 | 0.35 | 0.35 | 0.35 | 0.14 | 0.15 | 0.15 |
| NOx, NH3 | nitrate PM10 | mortality | 1.59 | 1.60 | 1.60 | 0.55 | 0.57 | 0.57 | 10.93 | 11.02 | 11.02 | 8.53 | 8.60 | 8.60 | 3.51 | 3.55 | 3.55 |
| | | chronic illness | 0.46 | 0.46 | 0.46 | 0.16 | 0.16 | 0.16 | 3.15 | 3.18 | 3.18 | 2.46 | 2.48 | 2.48 | 1.01 | 1.02 | 1.02 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.08 | 0.08 | 0.08 | 0.03 | 0.03 | 0.03 | 0.54 | 0.55 | 0.55 | 0.42 | 0.43 | 0.43 | 0.17 | 0.18 | 0.18 |
| *Total for NOx and NH3 emissions* | | | 2.43 | 2.45 | 2.45 | 0.84 | 0.87 | 0.87 | 16.60 | 16.81 | 16.81 | 13.02 | 13.13 | 13.13 | 5.35 | 5.40 | 5.40 |
| PM2.5 | PM2.5 | mortality | 7.12 | 7.14 | 7.24 | 2.29 | 2.34 | 2.50 | 19.46 | 19.74 | 20.98 | 15.99 | 16.21 | 17.17 | 1.82 | 1.92 | 2.12 |
| | | chronic illness | 2.11 | 2.12 | 2.14 | 0.67 | 0.69 | 0.73 | 5.56 | 5.64 | 5.95 | 4.58 | 4.64 | 4.88 | 0.53 | 0.56 | 0.61 |
| | | asthma attacks | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.35 | 0.35 | 0.36 | 0.11 | 0.12 | 0.12 | 0.97 | 0.98 | 1.04 | 0.79 | 0.80 | 0.85 | 0.09 | 0.10 | 0.10 |
| | | lung cancer | 0.07 | 0.07 | 0.07 | 0.02 | 0.02 | 0.02 | 0.21 | 0.21 | 0.21 | 0.17 | 0.17 | 0.17 | 0.02 | 0.02 | 0.02 |
| Coarse PM10 | coarse PM10 | mortality | 0.45 | 0.46 | 0.96 | 0.14 | 0.16 | 0.97 | 1.01 | 1.08 | 7.47 | 0.85 | 0.90 | 5.87 | 0.26 | 0.29 | 1.31 |
| | | chronic illness | 0.13 | 0.14 | 0.26 | 0.04 | 0.05 | 0.25 | 0.29 | 0.31 | 1.88 | 0.24 | 0.26 | 1.48 | 0.08 | 0.08 | 0.34 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.02 | 0.02 | 0.05 | 0.01 | 0.01 | 0.05 | 0.05 | 0.05 | 0.37 | 0.04 | 0.04 | 0.29 | 0.01 | 0.01 | 0.07 |
| *Total for direct PM10 emissions* | | | 10.27 | 10.31 | 11.09 | 3.29 | 3.38 | 4.63 | 27.57 | 28.03 | 37.93 | 22.69 | 23.05 | 30.74 | 2.82 | 2.98 | 4.57 |
| SOx, NH3 | sulfate PM10 | mortality | 4.63 | 4.84 | 4.84 | 1.72 | 2.16 | 2.16 | 12.21 | 14.21 | 14.21 | 10.08 | 11.66 | 11.66 | 1.60 | 2.33 | 2.33 |
| | | chronic illness | 1.31 | 1.35 | 1.35 | 0.48 | 0.59 | 0.59 | 3.29 | 3.79 | 3.79 | 2.73 | 3.12 | 3.12 | 0.44 | 0.62 | 0.62 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.23 | 0.24 | 0.24 | 0.09 | 0.11 | 0.11 | 0.61 | 0.71 | 0.71 | 0.50 | 0.58 | 0.58 | 0.08 | 0.11 | 0.11 |
| *Total for SOx and NH3 emissions* | | | 6.17 | 6.43 | 6.43 | 2.28 | 2.85 | 2.85 | 16.12 | 18.71 | 18.71 | 13.32 | 15.37 | 15.37 | 2.13 | 3.07 | 3.07 |
| VOCs | organic PM10 | mortality | 0.04 | 0.08 | 0.08 | 0.02 | 0.08 | 0.08 | 0.48 | 0.83 | 0.83 | 0.37 | 0.64 | 0.64 | 0.29 | 0.43 | 0.43 |
| | (SOA) | chronic illness | 0.01 | 0.02 | 0.02 | 0.00 | 0.02 | 0.02 | 0.14 | 0.21 | 0.21 | 0.10 | 0.17 | 0.17 | 0.08 | 0.12 | 0.12 |
| | | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | RRAD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.04 | 0.02 | 0.03 | 0.03 | 0.01 | 0.02 | 0.02 |
| | acetaldehyde | oral cancer | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | benzene | leukemia | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| | 1,3-butadiene | cancer all sites | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 |
| | formaldehyde | oral cancer | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Sub-total for VOC emissions* | | | 0.06 | 0.10 | 0.10 | 0.02 | 0.11 | 0.11 | 0.64 | 1.09 | 1.09 | 0.50 | 0.85 | 0.85 | 0.41 | 0.59 | 0.59 |
| VOCs, NOx | O3 | asthma attacks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| | | lower resp illness | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.09 | 0.10 | 0.10 | 0.07 | 0.08 | 0.08 | 0.05 | 0.05 | 0.05 |
| | | upper resp illness | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 |
| | | eye irritation | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.10 | 0.11 | 0.11 | 0.08 | 0.09 | 0.09 | 0.05 | 0.05 | 0.05 |
| *Subtotal mortality effects* | | | 13.85 | 14.12 | 14.72 | 4.72 | 5.31 | 6.28 | 44.12 | 46.91 | 54.54 | 35.85 | 38.05 | 43.97 | 7.73 | 8.75 | 9.98 |
| *Subtotal cancer effects* | | | 0.07 | 0.07 | 0.07 | 0.02 | 0.03 | 0.03 | 0.22 | 0.22 | 0.22 | 0.18 | 0.18 | 0.18 | 0.05 | 0.05 | 0.05 |
| *Subtotal chronic morbidity effects* | | | 4.03 | 4.09 | 4.24 | 1.36 | 1.50 | 1.74 | 12.43 | 13.12 | 15.00 | 10.12 | 10.67 | 12.13 | 2.14 | 2.39 | 2.70 |
| *Subtotal acute morbidity effects* | | | 1.04 | 1.06 | 1.09 | 0.36 | 0.40 | 0.45 | 4.56 | 4.74 | 5.13 | 3.63 | 3.77 | 4.08 | 1.45 | 1.52 | 1.58 |
| *Subtotal ambient PM10* | | | 18.63 | 18.99 | 19.77 | 6.34 | 7.10 | 8.35 | 58.95 | 62.57 | 72.47 | 47.92 | 50.77 | 58.46 | 10.03 | 11.35 | 12.94 |
| *Subtotal ambient O3* | | | 0.04 | 0.04 | 0.04 | 0.01 | 0.02 | 0.02 | 0.25 | 0.27 | 0.27 | 0.19 | 0.21 | 0.21 | 0.12 | 0.13 | 0.13 |
| *Subtotal ambient NO2* | | | 0.30 | 0.30 | 0.30 | 0.10 | 0.11 | 0.11 | 2.05 | 2.07 | 2.07 | 1.60 | 1.61 | 1.61 | 0.66 | 0.66 | 0.66 |
| *Subtotal ambient CO* | | | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.08 | 0.08 | 0.08 | 0.06 | 0.07 | 0.07 | 0.54 | 0.54 | 0.54 |
| ***Total all emissions, pollutants, effects*** | | | 18.99 | 19.35 | 20.13 | 6.46 | 7.24 | 8.49 | 61.33 | 65.00 | 74.90 | 49.78 | 52.67 | 60.36 | 11.37 | 12.71 | 14.31 |

**PRELIMINARY EFFORT AT DETERMINING**

**THE SOCIAL COST PER TON-MILE**

**OF ON-ROAD GASOLINE AND DIESEL VEHICLES**

Vehicle Plus Upsteam Emissions, Health Risk Cost, $'s/1000 mi.
Criteria pollutant cost as per UC Davis Report #11 (high emphasis on PM, low emphasis on CO)
$CO_2$ @ $15 / short ton
Gasoline/Diesel @ $1.25/gal. and $1.15/gal.

| | LDGC | LDDC | LDGT | ***LDDT**** | HDGT | HDDT |
|---|---|---|---|---|---|---|
| Criteria Emis. $/1000 mi. | 8.26 | 19.35 | 13.93 | ***13.93*** | 29.46 | 65.00 |
| $CO_2$ $/1000 mi. | 6.5 | 6.3 | 8.7 | ***5.2*** | 22.9 | 25.3 |
| | (28mpg) | (28mpg) | (21mpg) | ***(31mpg)*** | (8mpg) | (7mpg) |
| Fuel $/1000 mi. | 45 | 41 | 60 | ***37*** | 156 | 164 |
| Ton Miles/ 1000 mi. | 1580 | 1800 | 2100 | ***2100*** | 8000 | 30000 |
| Emis. Cost $/Ton Mile | .009 | .014 | .011 | ***.009*** | .007 | .003 |
| Social Cost (Emis. + Fuel) $/Ton Mile | .038 | .037 | .039 | ***.027*** | .026 | .008 |

* Potential commercial result of DOE's "Light Truck Clean Diesel" technology development program.