was typical of modern rail transit, I meant typical only with respect to energy considerations—its energy construction cost per system-mile is the same as that of three other modern systems (Atlanta, Baltimore, and Washington, D.C.); and its operating energy per vehicle-mile is the same as that of the only other fully operating modern system (Philadelphia).

2) I certainly don't believe in the blanket encouragement of highway construction.

Orski also makes two suggestions for changing the analysis. I am happy to take his advice. First, he suggests that I deflate all costs to 1963 dollars before computing their energy content. If the Federal Highway Administration construction cost index is used, BART would have cost $962 million in 1963, and the 67.1 lane-miles of highway that BART replaces would have cost $26.4 million.

Second, Orski suggests that I take into account the extra cost of highway bridge building. We know that BART has removed enough traffic from the San Francisco Bay Bridge to reduce highway needs by about three-fifths of a lane (*2*, p. xv). The cost for the eight-lane Southern Crossing bridge proposed for San Francisco would have been $144 million in 1972. Buying one lane's worth of that, instead of the three-fifths of a lane which is needed, would have cost $11.1 million in 1963.

Adding the cost of the bridge to the highway estimate above and converting both this figure and the BART cost into 1963 energy equivalents shows that BART cost 7.1×10^{13} Btu's more than the highways it replaced.

If the only alternative to BART were a 14-mile-per-gallon automobile, then BART's saving of operating energy would be 680 Btu's per passenger-mile, which implies that it would take 237 years for BART to repay even its construction energy. (The payback time against a 27.5-mile-per-gallon automobile is infinite.)

Hence my original conclusion that BART is an energy waster. This does not imply that it should not have been built, though, as there are other potential benefits from such systems—which Orski and I agree must be evaluated on a case-by-case basis.

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References

1. C. Lave, *Science* **195**, 595 (1977).
2. R. Ellis and A. Sharret, *Transportation and Travel Impacts of BART: Interim Service Findings* (Report No. FR 6-3-75, Peat, Marwick, Mitchell, San Francisco, 1976), pp. 71 and 165.

Radioactive Waste Disposal: An Environmental Standard

The National Academy of Sciences–National Research Council's Committee on Radioactive Waste Management has recently established a panel to study how the implementation of an environmental standard governing the disposal of high-level radioactive waste in geological formations can be verified. Although the standard has yet to be determined, for purposes of this study it is assumed to lie within the range of 0 to 25 millirems per person per year and to be applicable for at least 1000 years.

Because of the long time scale involved and the possibility that typical monitoring techniques may adversely affect the integrity of the waste disposal site, verifying the implementation of an environmental standard, as described above, is a unique and difficult task. Consequently, to assist the panel in carrying out its study, I am requesting that *Science* readers communicate any information, ideas, or philosophical approaches regarding this problem to Dr. Richard Milstein, Staff Officer, Committee on Radioactive Waste Management (JH 804), National Academy of Sciences, 2101 Constitution Avenue, NW, Washington, D.C. 20418.

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The Diesel's Advantages

It was satisfying to see in *Science* a sensible and accurate assessment of the automobile pollution situation (Editorial, 5 Aug., p. 517).

The diesel car, while it has problems, such as aldehyde and particulate emissions, roughness, noise, and cold-starting, has unequaled advantages and promise as an optimum solution to the difficult compromise between energy and pollution.

Other types of engine can be made to meet the Clean Air Act's ultimate emission specifications of 0.4 gram of hydrocarbons (HC's), 3.4 grams of carbon monoxide (CO), and 0.4 gram of nitrogen oxides (NO_x) per mile, but only by the use of catalysts in combination with a precarious balance of adjustment not likely to survive very long if present automobile maintenance practices remain the same. People will destroy catalysts by using leaded fuel because it is 3 to 4 cents cheaper, they will deactivate exhaust-gas recirculation systems to improve performance and economy, and they will neglect ignition and spark plug maintenance until misfiring takes place. Programs to coerce the car owner into maintaining the emission controls in his car will be expensive, only partly effective, and politically unpopular.

The diesel car requires no add-on units or precise adjustments to maintain its low level of emissions (0.3 gram of HC's, 2 grams of CO, and 1.5 grams of NO_x per mile, even for a good-sized car) or to maintain its fuel economy. For this reason, a new diesel car's margin of economy (25 percent) over a new gasoline car can be assumed to be larger when the lives of the two types of car are considered. Finally, diesel fuel has some formidable advantages over gasoline: (i) it requires no toxic additives, such as lead; (ii) it is not explosive and makes no evaporation pollution; and (iii) it yields more energy at a lower cost in energy and money for refining. But the limits on NO_x emissions presently specified by the Clean Air Act make use of the diesel in the United States impossible, and little attention has been paid to diesel development in this country.

If all passenger cars were putting out not more than 1.5 grams of NO_x per mile, emissions would be small in comparison with what they are now, and most probably small in comparison with what they would be if all cars had been built to meet the 0.4-gram limit when new (given current maintenance practices). Not only would it be a very large economic penalty to enforce a high level of maintenance on all car owners, but it would require facilities that do not exist at present.

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New Texico?

We in New Mexico have for decades been observing the gradual intrusions of Texans into our space, but not until Deborah Shapley (News and Comment, 8 July, p. 138) made Arizona contiguous with Texas did we realize the extent and suddenness with which this massive transposition has occurred.

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