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Technologies for Improving the Fuel Economy of Passenger Cars and Light-Duty Trucks

This chapter examines a variety of technologies that could be applied to improve the fuel economy of future passenger vehicles. It assesses their fuel economy potential, recognizing the constraints imposed by vehicle performance, functionality, safety, cost, and exhaust emissions regulations.

The committee reviewed many sources of information related to fuel economy-improving technologies and their associated costs, including presentations at public meetings and available studies and reports. It also met with automotive manufacturers and suppliers and used consultants to provide additional technical and cost information (EEA, 2001; Sierra Research, 2001). Within the time constraints of this study, the committee used its expertise and engineering judgment, supplemented by the sources of information identified above, to derive its own estimates of the potential for fuel economy improvement and the associated range of costs.

In addition, after the prepublication copy of the report was released in July 2001, the committee reexamined its technical analysis. Representatives of industry and other groups involved in fuel efficiency analysis were invited to critique the committee's methodology and results. Several minor errors discovered during this reexamination have been corrected in this chapter, and the discussion of the methodology and results has been clarified. The reexamination is presented in Appendix F.

FUEL ECONOMY OVERVIEW

To understand how the fuel economy of passenger vehicles can be increased, one must consider the vehicle as a system. High fuel economy is only one of many vehicle attributes that may be desirable to consumers. Vehicle performance, handling, safety, comfort, reliability, passenger- and load-carrying capacity, size, styling, quietness, and costs are also important features. Governmental regulations require vehicles to meet increasingly stringent requirements, such as reduced exhaust emissions and enhanced safety features. Ultimately these requirements influence final vehicle design, technology content, and—the subject of this report—fuel economy. Manufacturers must assess trade-offs among these sometimes-conflicting characteristics to produce vehicles that consumers find appealing and affordable.

Engines that burn gasoline or diesel fuel propel almost all passenger cars and light-duty trucks. About two-thirds of the available energy in the fuel is rejected as heat in the exhaust and coolant or frictional losses.[1] The remainder is transformed into mechanical energy, or work. Some of the work is used to overcome frictional losses in the transmission and other parts of the drive train and to operate the vehicle accessories (air conditioning, alternator/generator, and so on). In addition, standby losses occur to overcome engine friction and cooling when the engine is idling or the vehicle is decelerating.

As a result, only about 12 to 20 percent of the original energy contained in the fuel is actually used to propel the vehicle. This propulsion energy overcomes (1) inertia (weight) when accelerating or climbing hills, (2) the resistance of the air to the vehicle motion (aerodynamic drag), and (3) the rolling resistance of the tires on the road. Consequently, there are two general ways to reduce vehicle fuel consumption: (1) increase the overall efficiency of the powertrain (engine, transmission, final drive) in order to deliver more work from the fuel consumed or (2) reduce the required work (weight, aerodynamics, rolling resis-

[1]Theoretically gasoline or diesel engines (and fuel cells) can convert all of the fuel energy into useful work. In practice, because of heat transfer, friction, type of load control, accessories required for engine operation, passenger comfort, etc., the fraction used to propel the vehicle varies from as low as zero (at idling) to as high as 40 to 50 percent for an efficient diesel engine (gasoline engines are less efficient). Further losses occur in the drive train. As a result, the average fraction of the fuel converted to work to propel the vehicle over typical varying-load operation is about 20 percent of the fuel energy.