1.1.2 HEAVY VEHICLES

Technology Description

Freight vehicles (Class 7 and 8 trucks and rail) and commercial delivery vehicles (Class 2b through Class 6) are essential to the economic vitality of the nation. Diesel engines are the dominant motive source for these vehicles. Vehicle efficiency could be increased by as much as 100% if all current research such as new generation of ultra-high-efficiency diesel engines (using advanced emissions-control technology), reduced aerodynamic drag, rolling resistance, and parasitic power losses is successful. Development and commercialization of engines with higher efficiency will significantly reduce transportation oil use, emissions (including CO_2), and related costs to the economy. Increased use of lightweight materials will contribute to these goals.

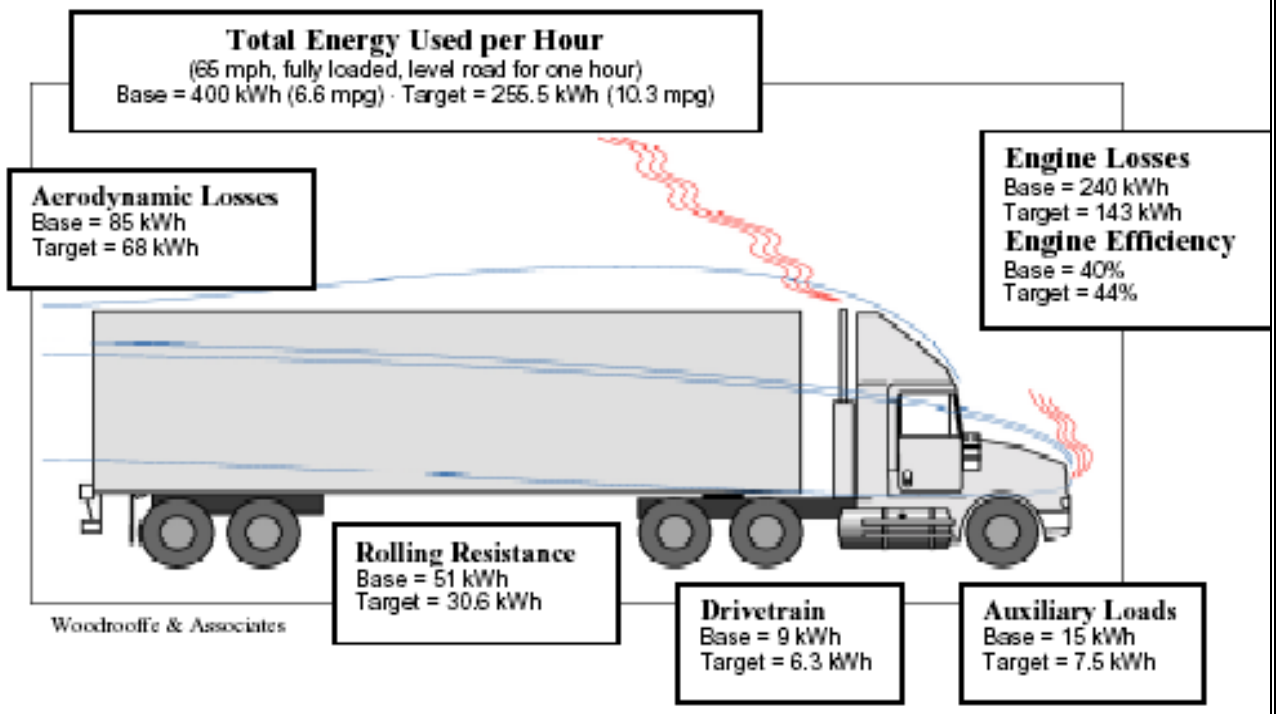

Fig. 4.1. Class 8 truck energy audit.

System Concepts

- Four-stroke, direct-injection diesel engines (with high peak-cylinder pressures, thermal barrier coatings, high-pressure fuel injection systems, and turbocharging) are being developed.
- Lightweight materials, truck aerodynamics, and advanced tires are being developed to improve overall fuel economy.
- Hybrid vehicles with regenerative braking may have application in local delivery vehicles.
- Vehicle electrification can reduce parasitic losses from auxiliary loads and help reduce idling losses.

Representative Technologies

- High-pressure, common-rail fuel injection, bottoming cycles, and friction and wear reduction.
- Software technology to improve vehicle aerodynamics.

Technology Status/Applications

- Virtually all heavy-duty trucks and the entire fleet of locomotives are diesel powered, and there is an increasing trend to convert medium-duty trucks to diesel fuel as well. Advanced combustion concepts – resulting in higher efficiency and lower emissions while maintaining power density – are needed. New advanced technologies for emission controls are required.

- Fuel cells are considered a long-term option. A locomotive fuel cells program is being pursued by industry.
- Software tools are being developed to provide design guidance to reduce aerodynamic drag.

Current Research, Development, and Demonstration

RD&D Goals

- Engine systems including the integration of fuel, engine, and aftertreatment. Specific technology goals are:
  - Development and demonstration of a commercially viable, emissions-compliant engine system for Class 7-8 highway trucks that improves the system efficiency by 20% (from current 42% to 50%) by 2010 and demonstrate 55% efficiency in the laboratory by 2012.
  - Identification of a commercially viable, domestically produced non-petroleum diesel-blending agent that would enable a 5% displacement of diesel fuel by 2012.
- Parasitic losses account for 40% of the total fuel energy used to move a heavy vehicle down the road. These losses arise from aerodynamic resistance, rolling resistances, drivetrain, and auxiliary load losses. Specific 2012 technology goals are:
  - Develop and demonstrate advanced technology concepts that reduce the aerodynamic drag of a Class 8 tractor-trailer combination by 20% (from current 85 kWh to 68 kWh) in a practical, efficient, and commercially viable manner.
  - Develop and demonstrate commercially viable technologies that reduce auxiliary loads by 50% (from current 15 kWh to 7.5 kWh) for Class 8 tractor-trailers.
  - Develop and demonstrate a 10% reduction (from current 51 kWh to 46 kWh) in tire-rolling resistance values vs. existing best-in-class standards without compromising cost or performance.
  - Develop and demonstrate commercially viable lightweight material and manufacturing processes that lead to a 5,000-pound reduction in Class 8 tractor-trailer combinations (a 15-20% weight reduction)
  - Develop and demonstrate commercially viable technologies that increase heat-load rejected by thermal management systems by 20% without increasing radiator size.
- Class 7 and 8 trucks, alone, consume more than 825 million gallons of diesel fuel per year when idling. Technology goals are to reduce fuel use and emissions from idling heavy vehicles by greater than 65%. Specific technology goals are:
  - Development and demonstration of a commercially viable 5 kW, $200/kW, diesel-fueled, internal-combustion engine auxiliary power units by 2007 (0.2 gallons of diesel fuel per hour; 200 lbs. weight; maximum 0.5 cubic-meter size; meeting prevailing emission standards; cooling and fuel systems integrated into vehicle platform, less than 65 dB noise inside cab; noise, vibration, and harshness as good or better than the prime mover engine).
  - Develop and demonstrate a commercially viable fuel cell auxiliary power unit system in the 5-30kW range, capable of operating on diesel fuel at a delivered cost of $400/kW by 2012.

RD&D Challenges

- Technical challenges exist to improving engine efficiency, thus reducing CO_2 emissions, while meeting emission regulations.
- Advanced technology often involves more durable materials, additional components, or additional manufacturing processes, all of which can add cost and weight.
- Meeting tighter emissions regulations can result in an additional load on the engine – such as additional backpressure – which can increase fuel consumption.

RD&D Activities

- DOE is working closely with industry in the 21st Century Truck Partnership.
- The Environmental Protection Agency's National Vehicle Fuel Emissions Laboratory plans to add advanced heavy diesel cycle engines and innovative hybrid drive-train systems for urban delivery trucks to its Advanced Automotive Technology Program.
- Department of Defense Advanced Research Projects Agency, California Energy Commission, and the California Air Resources Board cosponsor R&D projects with DOE.
- DOE sponsors analytical and modeling work.

Recent Progress
• New conceptual model of in-cylinder soot formation has been developed. • Advanced multicylinder engine demonstrated more than 90% reduction in NO_x and particulate matter. • Demonstrated 51% reduction in aerodynamic drag for Class 8 trucks in wind tunnel tests. • Electrification of underhood components – such as air compressors, water pumps, and oil pumps – was shown to reduce fuel consumption by up to 18%.
Commercialization and Deployment Activities
• The diesel engine is the workhorse of all the heavy-duty transport modes that are responsible for most of the nation's intercity freight movement, the lifeblood of the economy. Because of low fuel consumption, high reliability, and long service life, it is widely acknowledged that the diesel engine will continue to dominate heavy-duty transport propulsion for many years. • The strong coupling between efficiency and emissions controls is a significant barrier. Many of the engine design options currently available to manufacturers for emissions reductions involve a fuel economy penalty of 10%-20%. In the absence of significant technology advancements, future emission regulations could detrimentally affect the historical trend toward higher diesel-engine efficiency. • All new technologies must meet high durability requirements. **Market Context** • Stiff domestic and international competition from European and Japanese diesel-engine manufacturers has reduced domestic market share. U.S. manufacturers have limited resources to identify, research, develop, and commercialize many of the promising advanced emission technologies. Effective partnership with national labs is essential for successful completion of advanced automotive research activities.