Evaluations of 1997 Fuel Consumption Patterns of Heavy Duty Trucks

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The proposed 21st Century Truck program selected three truck classes for focused analysis. On the basis of gross vehicle weight (GVW) classification, these were Class 8 (representing heavy), Class 6 (representing medium), and Class 2b (representing light). To develop and verify these selections, an evaluation of fuel use of commercial trucks was conducted, using data from the 1997 Vehicle Inventory and Use Survey (VIUS). Truck fuel use was analyzed by registered GVW class, and by body type.

GVW Class Analysis. Evaluation of the VIUS fuel use data for the classes of truck from GVW Class 2b to 8 indicated that most fuel use for such trucks occurs in Class 8 trucks on long trips in relatively steady speed interstate operation (see slides 3-8). The remaining fuel use appeared to be comparable for the other two leading consumers – Class 2b and 6 (slides 5 and 6). It was observed that the proportion of gasoline use increased truck GVW class dropped, with more reported gasoline than diesel use in classes 2b, 3 and 5 (slide 6). When classified by truck body type, it was found that pickup trucks and multistop step vans used more gasoline than diesel fuel (slide 7), with other body types using more diesel. It was also observed that, in contrast to the distribution of fuel use, the *number* of commercial light (Class 2b-4) and medium (Class 5-7) duty trucks is about twice that of heavy duty trucks (slide 10). The overwhelming majority of fuel use of Class 8 trucks was shown to be in trips of 100 or more miles in length. In contrast, the majority of fuel use of commercial light and medium duty trucks was shown to be in trips typically less than 100 miles in length (slide 11). Due to the great volume of fuel used in Class 8 trucks, the portion of fuel use of these trucks in trips less than100 miles was found to be comparable to, but still greater than the totals for either light or medium duty trucks (slide 12). For diesel fuel, the dominance of Class 8 consumption even in trips under 100 miles is notable, with diesel use in Class 8 trucks in trips under 100 miles greater than the sum of diesel use of all other truck types.

Body Type Analysis. In addition to looking at the fuel consumption and trip making patterns of trucks by gross vehicle weight (GVW) class, we looked at consumption by truck body type. The top ten body types, in terms of number of trucks, are listed in a table in slide 13. Within these top ten, by number of trucks, one also finds the top seven body types by fuel consumption. The top three fuel consuming body types – basic enclosed van, basic platform, and insulated refrigerated van - consumed the vast majority of fuel on trips of 100 miles or more in length. Tank trucks, the sixth most prolific fuel consumer, also consumed the majority of fuel on these longer trips. Dump trucks, pickup trucks, and multistop step vans consume considerably more fuel on trips less than 100 miles in length (slide 14).

As far as the *number* of trucks making typical trips of less than 100 miles is concerned, the vast majority of trucks are utilized in this fashion (slide 15). For pickup and dump trucks, a very small proportion of trips is for those greater than 100 miles in length. Only the basic enclosed van and insulated refrigerated van appear to be typically used in trips of more than 100 miles for the majority of trips (slide 15).

Class 8 Matching of Simulated to Field Fuel Economy. Using VIUS, the average loads and miles per gallon patterns of Class 8 trucks as a function of typical trip length were determined. Several candidate driving cycles for Class 8 trucks were examined by using them within the NREL Advanced Vehicle Simulator (ADVISOR) model to simulate fuel consumption of a typical Class 8 truck, given loads specified by VIUS by trip length, and truck attributes recommended by industry (slides 16-18 and 20). It was estimated, by use of the ADVISOR results and by construction of a candidate composite driving cycle, that the fuel economy predicted for known loads could be plausibly matched to VIUS field data on fuel consumption (slide 20). By examining the VMT of trucks by type of road, as compiled by the Federal Highway Administration, the notion of "city" vs. "highway" fuel consumption by medium and heavy duty trucks was examined (slide 19). A couple of possible city/highway breakouts based on the FHWA data gave results close to those obtained in the weighting of driving cycle Class 8 mpg results to develop a match to field data from VIUS (slides 19 and 20). The results also suggested that fuel consumption for each of three trip length categories could be adequately characterized. This was done by constructing weighted combinations of two steady interstate speeds (65mph and 70 mph) and two considerably slower variable speed urban driving cycles. NREL and WVU had established these urban cycles by chasing Class 8 trucks (slides 17 and 18). Effects of overnight and truck stop idling were also taken into account (slide 20, 21). These results are encouraging, indicating that, in conjunction with VIUS, the recently developed vehicle simulation models such as ADVISOR and PSAT allow a very detailed evaluation of the probable in-use driving behavior of trucks.

These vehicle simulation model s allow a user to plug in assumptions concerning

- Frontal area
- Coefficient of drag
- Rolling resistance
- Truck Mass
- Truck Load
- Transmission type
- Engine (and fuel) type
- Driving cycle

and obtain an estimate of the fuel consumption of the specified truck.

For each of the Class 8 simulations whose results are shown on slide 20, frontal area, coefficient of drag, rolling resistance, truck mass, transmission type, and engine type were held constant, consistent with industry suggested baseline data. Load was varied to be consistent with load carried on the trip of the specified length, as developed from the VIUS. Driving cycles were varied as noted on slide 20.

In slide 21 we summarize the range of changes in fuel economy obtained with the ADVISOR model for the Class 8 truck, by varying coefficient of drag, rolling resistance, engine efficiency, average load, and elimination of "off cycle" idling. A range was obtained because we constructed the estimates for the four driving "cycles" (where steady 65 and 70 mph are considered cycles). Professional judgment was used to provide an upper bound estimate of fuel saving through hybridization, by truck GVW class (slide 21).

The VIUS survey provides information on type of truck, including but not limited to GVW class and on type of fuel, type of trip and type of owner. For each way of looking at a truck an average fuel economy and load can be obtained. Many more experiments than conducted for this exercise are therefore possible and will be reported elsewhere.

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