Essential Power Systems Workshop

December 12 & 13, 2001
US DOT OHVT
Background

• USDOT/DARPA Advanced Vehicle Program
• AVP Sponsored: Fuel Cell Auxiliary Power System Concept Demonstration
• Freightliner, UC Davis, Ballard / XCELLSiS Team
Study Motivation – WHY?

• Potential to:
  – Reduce Fuel Consumption
  – Reduce Exhaust Emissions
  – Reduce Noise Emissions
  – Improve Safety via Increasing Quality of Driver Rest Periods
  – Reduce Overall Operations and Maintenance Costs
Fuel Cell APU

- Simplest Concept Demonstration Concept and Configuration
- 1.5 KW D/C and A/C Power
- Climate Control – Electric Air Conditioning, Phase Change System, Diesel Fueled Heater
- A/C powered appliances
- Hydrogen Fuel – to demonstrate concept – not necessarily a potential production system fuel
But…WHY IDLE?

• Several Reasons – Anecdotal
  – Climate Control
  – Noise Control
  – Reduce Cold Weather Engine/Fuel Problems
  – Security
  – Privacy
  – Others

• How much of the above?
Technical Papers

• Truck Idling Trends: Results of a Pilot Survey in Northern California SAE Paper #2001 01 2828
• Demonstration of a Proton Exchange Membrane Fuel Cell Auxiliary Power Source for Heavy Trucks, SAE Paper # 2000 01 3488
• Others….National Research Council, Transportation Research Journal D.
Quantification Process

• Utilized the AVP Program to begin the initial analysis of what are the motivations
• Present results to the community for further concept definition of technical approaches to reduce need to idle
Truck Idling Trends:
Results of a Pilot Survey in Northern California

Christie-Joy Brodrick, Ph.D.
Institute of Transportation Studies, U.C. Davis

S. William Gouse, III
Freightliner LLC
SAE Paper # 2001 01 2828
(Presented at Truck & Bus)
Introduction

- The extent of idling is highly uncertain and varies with season, operation, and route.
- One study uses 3.3 to 16.5 hours per day as an idling duration range.
- It is estimated that over 400,000 line-haul trucks and an additional 400,000 short-haul trucks idle more than four hours per day.
Consequences

- Air pollution, noise, and energy consumption, as well as increased business operating costs, such as accelerated engine wear and increased maintenance.

- The U.S. Department of Energy estimates that $1.17 billion is spent each year on fuel for idling, and an additional $1 billion is spent on engine wear and maintenance due to idling.

- As a result, several entities have promulgated new idling bans in an effort to mitigate the effects of heavy-duty truck and bus idling.
Potential Alternatives and Challenges

- Auxiliary power units
- Auxiliary climate control devices
- Electrification of truck stops

- Understand cost-effectiveness and make rational choices between these alternatives
- Modest data is available on truck market size and performance requirements
- Virtually no data is available on truck driver idling behavior, such as idling time, idling location, and accessory
Objectives

• Assess truck driver attitudes toward idling and idling alternatives
• Characterize idling behavior, such as idling time, idling location, and accessory use
• Assess how these will influence adoption of the technologies.
Methodology

- A pilot survey of 233 line-haul truck drivers was administered in Northern California.
- A 15-minute personal interview survey was administered at four locations in Northern California.
- The locations included a highway rest area at Dunnigan, an urban truck stop in Sacramento, a truck fuel station in Sacramento, and an agricultural inspection station in Truckee.
- Approximately 1 in 10 truck drivers agreed to participate in the survey.
Hypothesis

• Truck drivers idle to power mainly the heater and air conditioning as opposed to other accessories.
• Truck drivers idle an average of 6 hours per day.
• Truck drivers’ idle times are much longer at truck stops than at rest areas.
• Truck drivers require an average of 5 kW of auxiliary power with more power necessary for peak power demands and high accessory loads.
Hypothesis

- Truck drivers are familiar with and have rejected existing auxiliary climate control and power sources due to poor performance of existing retrofitted systems.
- Truck drivers already have programs and technologies to reduce idling.
- Truck drivers are aware of fuel consumption and associated costs incurred during idling.
- Truck drivers are willing to pay for alternatives to idling that have a payback period of 2 years or less.
General Data Trends

• Nearly all of the truck drivers surveyed (91%) drove Class 8 trucks with sleeper cabs (cabs with a bunk for sleeping).

• Owner-operators represented 30 percent of the population while company drivers represented 70 percent.

• Company drivers of large fleets (fleets with greater than 100 vehicles) represent the majority (59%) of the company drivers interviewed.
General Data Trends

• Survey results showed that 42% of truck drivers smoke.
• The majority of the truck drivers surveyed drove trucks that were model year 1998 or later.
• Company drivers in large fleets tend to have the newest vehicles, and owner operators have the widest range of vehicle ages.
Motivations for Idling

• Conventional wisdom is that truck drivers idle the engines to power climate control devices, sleeper compartment accessories, and to avoid start-up problems in cold weather.

• The truck drivers we surveyed reported that they idle primarily for climate control.

• Of the truck drivers surveyed, 67% idled to power the heater and 83% reported they idled to power the air conditioner.

• This suggests that climate control devices alone could be used to reduce idling.
Motivations for Idling

• A very small percentage of truck drivers (13%) indicated that they idled for other reasons when they did not need climate control.

• Those with newer trucks had a higher incidence of idling for reasons other than climate control, but they also had the most accessories.

• It is interesting to note that smokers appear to idle solely for climate control and may idle more than any other group.
Motivations for Idling

• Other reasons given by truck drivers for idling included air pressure, power take-off, safety, and noise reduction.

• One driver mentioned that it was unsafe to even open the side vent due to the potential of being sprayed with ether and having the truck stolen.

• A second driver noted that idling could reduce the intrusion of outside noise.

• The noise reduction motivation could explain why 17% of drivers indicated they idle “because other drivers are idling”.
Idling Time Estimates

• Reliable truck driver idling time data proved to be elusive throughout the study.
• The study attempted to quantify the number of times weekly that drivers stop at urban and rural parking lots, urban and rural truck stops, highway rest areas, and on the side of the road.
• Truck drivers reported they make frequent stops for a variety of reasons, and they had difficulty accurately recalling idling durations and locations.
Engine Speed and Load During Idling

- The engine speed at idling affects the level of fuel consumption.
- Previously truck drivers have reported that they increase engine speed to provide more power to accessories, especially climate control accessories.
- The truck drivers were asked to provide their engine speed during the three most prevalent idling conditions: standby, warm-up, and accessory use idling.
Engine Speed and Load During Idling

- About half of the truck drivers reported typical warm-up and stand-by engine speeds of 550-750 rpm.
- More than one-third of the truck drivers reported warm-up and stand-by idling speeds between 750 and 1050 rpm.
- For truck drivers that idled at over 750 rpm during stand-by and warm-up, the idling speed was increased when accessories were used.
- Truck drivers that idled at less then 750 rpm during stand-by and warm-up tended to decrease their idling speed during accessory use.
Accessories

• A stereo, CB radio, heater using engine heat, and air-conditioning powered by the engine.
• There was very little variation in accessories between drivers in company fleets and owner-operators, with the exception of TVs and computers.
• Of the owner-operators, 71% had a TV, compared to 57% of company drivers.
• Of the truck drivers in large fleets (fleets greater than 100 trucks), 52% had computers, compared with only 26% for owner-operators and 20% for smaller fleets.
Accessories

• To estimate the total power needs of truck drivers, this survey data on accessories was supplemented with product information on commercially available appliances.

• The initial peak power draws as well as unaccounted for electrical loads and losses may require a 6 kW or larger APU.

• The 4-6 kW steady power demand is consistent with higher power demand estimates from other sources.
Attitudes Toward Idling

- A large number of truck drivers (70%) reported they already have taken steps to reduce idling.
- The survey shows that 70% of the owner-operators say they are following the developments in alternatives to truck idling, while 50% of company drivers are following these developments.
- Fleets larger than 24 vehicles and owner-operators were more likely to take steps to reduce idling than were fleets smaller than 24 vehicles.
- Of the owner-operators, 6% were given a bonus for improving fuel efficiency while 16% of company drivers were given a bonus.
Alternatives to Idling - Truck Based

Truck drivers reported that they use multiple alternatives to idling:

• Manual engine shut-off
• Pre-programmed engine shut-off after a certain idling duration (i.e., auto shut-off)
• Engine shut-off at a specific temperature, battery state of charge, or other condition (i.e., “idle optimizer”)
• Remote satellite engine shut off
• Auxiliary units (including heaters, coolers, and auxiliary power units)
Alternatives to Idling

• The idle optimizer was the technology that received the most unsolicited comments.
• When asked if they use auxiliary climate control or power units, only 5 percent of truck drivers reported they had one of these.
• The results should not be considered representative of the entire US, since the survey was conducted in Northern California, which has a different climate than many other states.
Awareness of Consequences of Idling

- Generally, truck drivers were much less familiar with fuel consumption than with idling control measures.
- An electronic dash readout of fuel economy was available in 45% of the trucks.
- Not surprisingly, newer trucks tended to have the fuel economy dash read-out function.
- For owner-operators, 18% of the older trucks (i.e., trucks 1998 or older) had dash fuel economy readout, while 47% of the newer trucks (i.e., trucks newer than 1998) had a readout.
Awareness of Consequences of Idling

• This difference was less pronounced for company vehicles, where 39% of the older trucks had dash fuel economy readout compared to 57% of the newer trucks.

• A higher percent of company drivers (52%) had this device than did owner-operators (30%).

• While most truck drivers knew their on-road fuel economy (96%), fewer (36%) knew how to read their dash readout to obtain fuel economy during idle at low or high engine idling speed.
Awareness of Consequences of Idling

- Of the 107 drivers who reported having a dash readout of fuel economy, less than 20% of the truck drivers reported realistic fuel economy during idling.

- Many drivers repeated to us the 1 gallon per hour fuel consumption that is commonly discussed in the trucking industry.

- This may indicate that the drivers are misinterpreting or not reading the dash readout of fuel economy.

- To test this, we asked the last 107 drivers we surveyed to demonstrate retrieving data from the dash readout.

- Less than 5% could retrieve idling fuel consumption data from the dash readout.
Opinion on Alternatives to Idling

• The prevailing opinion in the trucking industry is that further idling restrictions are not feasible, but the industry is receptive to alternative technologies.
• We provided the truck drivers with a series of statements and asked whether they strongly agreed, agreed, were neutral, disagreed, or strongly disagreed with the statements.
• Many truck drivers were resistant to using this five-point Likert scale and preferred to report either agreeing, disagreeing or being neutral.
• So, the analysis is presented in terms of this three-point scale.
Opinion on Alternatives to Idling

- Of all the surveyed drivers, 68% agreed that they would support an incentive-based program to reduce idling, and 67% of all drivers were willing to stop idling to help reduce exhaust emissions.
- Of the total surveyed population, 46% believed that companies or governmental agencies should enact policies to reduced idling time.
- When asked if the government, as opposed to their company, should enact idling policies, truck drivers became much more skeptical.
- Most drivers do not support idle reduction legislation, with 24% of drivers saying that cities should enact idling bans. is presented in terms of this three-point scale.
Opinion on Alternatives to Idling

• With a 2-year payback period, 82% of owner-operators would be willing to buy an idle-reducing device, while 63% of company drivers thought their company would do the same.

• Contact with companies is necessary to discern whether this difference between owner-operators and companies is true or simply due to the perception of the company drivers.
Conclusions

• In California, idling is largely done for climate control. This suggests that climate control devices alone could be used to reduce idling.

• Line-haul truck drivers surveyed require an average of 4-6 kW of power for a stereo, CB radio, light, refrigerator, and climate control found in the average truck.

• More power may likely be necessary for peak power demands.
Conclusions

• The amount of time line-haul trucks reported to have stopped is between 25 and 30 hours per week.
• It was not possible to accurately determine from the pilot survey the location, purpose, and duration of idling.
• Consulting driver logs or electronically monitoring trucks could yield more accurate data, including seasonal and geographic differences.
• Truck drivers were receptive to idling alternatives.
• Two-thirds of truck drivers surveyed support a program to reduce idling.
Conclusions

- Two-thirds of drivers reported they would purchase idling reduction technologies if the technology yielded a payback period of two years or less.
- Willingness to purchase auxiliary power units appears to be higher for owner-operators than for company drivers.
- With a 2-year payback period, 82% of owner-operators would be willing to buy an idle-reducing device, while 63% of company drivers thought their company would do the same.
- Contact with companies is necessary to discern whether this difference between owner-operators and companies is true or simply due to the perception of the company drivers.
Conclusions

• Truck stops appear to be a much more attractive option for electrification than rest areas by a 48% to 21% margin.

• Much of this discrepancy may be due to perceived safety problems with rest areas.

• This survey did not properly differentiate between using these areas for breaks or overnight.

• The next, full survey will quantify where the truck drivers are staying overnight, where they go for breaks, and the duration of time they spend at each place.
Conclusions

- The nationwide survey, which is in progress, will indicate how applicable the results are to the US in general.
- In addition to the survey, we believe data loggers and focus groups will be necessary to collect the idling duration and location data necessary to compare auxiliary power units to truck stop electrification.
- Focus groups are recommended to better understand the driver response to APUs and electrification.
- The appearance and perception of the new systems will need further clarification, which could be accomplished with a demonstration for truck drivers.