1.1.6 TRANSIT BUSES – URBAN-DUTY CYCLE, HEAVY VEHICLES

Technology Description

Current transit buses use large-displacement, slow-speed, four-stroke diesel engines as the prime propulsion system. Due to their high efficiency and reliability, diesel engines are the dominant power source for heavy-duty transit buses in the United States, and they are the preferred power source for commercial surface transportation worldwide. In a transit bus, the engine is coupled to a four- or five-speed automatic transmission, which drives through a differential within the solid rear axle that mounts dual rear tires, resulting in a direct (or nearly direct) relationship between wheel speed and engine speed. The engine also directly drives all major vehicle auxiliary systems, through belt, hydraulic, or gear drives or combinations thereof.

Conventional transit bus designs waste substantial energy through braking resulting in poor propulsion system efficiency. The current state of practice simply discards this braking energy as heat during deceleration; none of it is recovered. Past attempts have been made at energy recovery through hydraulic or pneumatic systems. The inherent inefficiency, size, weight, and added complexity of these systems precluded them from production consideration.

The urban duty cycle of transit buses (constant stop and start cycles with as many as 14 cycles every 10 minutes in the case of the CBD-14 driving cycle) means the engine, transmission, and auxiliary systems are most frequently operated in a transient mode. Transient operation in this type of drive system is a condition detrimental to the goals of high efficiency and low emissions.

System Concepts

- Hybrid electric propulsion systems using diesel engines in both parallel and series configuration.
- Lightweight materials including composite body structures and components.
- Clean fuel formulation including bio-gas, synthetic diesel, ultra-low sulfur petroleum diesel.
- Fuel cell systems as standalone propulsion systems and in hybrid configuration.

Representative Technologies

- Compressed natural gas spark-ignited engines.
- Diesel hybrid electric systems with current energy storage technologies.
- Exhaust after-treatment technology for both NO_x and particulates.

Technology Status/Applications

- Diesel buses are still the dominant technology; 20% of all new bus purchases are for natural gas buses.
- Clean fuel formulations continue to be evaluated including bio-diesel, synthetic diesel, and bio-gas.
- Diesel hybrid buses (both parallel and series hybrid) with current energy storage technologies are entering commercial infancy.
- Hydrogen fuel cell buses continue to be demonstrated.

Current Research, Development, and Demonstration

RD&D Goals

- Meet or exceed proposed EPA emissions standard for heavy-duty bus engines of 0.01 g/bhp-hr particulates and 0.20 g/bhp-hr of NO_x plus 0.14 g/bhp-hr of non-methane hydrocarbons (NMHC) by 2007. By 2015, have zero-emission or near zero-emission transit bus commercially available.
  - Advance hybrid electric drive systems in combination with fuel formulation and after-treatment.
  - Continue RD&D for advance energy storage options to enhance commercial viability of hybrid electric and ultimately fuel cell buses.
- Gross load passenger capacity increased from 53-88 to 100 passengers and seated passenger capacity increased from 43 to 50 on a two-axle bus. Transit buses with a maximum single-axle load no greater than 20,000 pounds at the gross vehicle weight with a full passenger capacity of 90-100 people by 2006.
  - Accelerate RD&D of composite body structure bus and bus components.
  - Accelerate broader deployment of composite body structure buses.
- By 2010, transit buses with 10-mpg (128,400 btu/gal equivalent) fuel efficiency at seated load weight on the CBD-14 driving cycle.
  - Advance hybrid electric drive systems with advanced energy storage technology.
  - Advance lightweight bus structures.
- Mean miles between failure (individual components) increased by 50%. Mean time to repair failure (individual components) reduced by 50%.
- By 2015, commercially viable fuel cell transit buses meeting all prevailing standard transit bus operating and maintenance requirements at less than twice the cost of a comparable transit vehicle. Incremental capital cost no greater than 50% compared to standard bus five years after commercial introduction.
  - Continued RD&D for fuel cell propulsion systems specifically designed for heavy-duty transit buses.
  - Continued RD&D for light-duty fuel cell hybrid fuel cell systems for buses.

RD&D Challenges

- Tradeoff between improving vehicle fuel efficiency and vehicle-exhaust emissions.
- Need to consider vehicle systems approach to vehicle fuel efficiency and emissions as opposed to current engine approach.
- Transit bus market volume too low to be technology driver. However, transit bus fleets are ideal platforms for the introduction of new technologies.
- Compact, lightweight, robust, reliable, and durable energy storage technology for hybrid electric and fuel cell buses.
- Cost, reliability, durability, and performance of hydrogen fuel cells need significant improvements for commercialization to be viable.

RD&D Activities

- DOT through FTA continues to be in the forefront of the RD&D of fuel cell buses and is developing a hydrogen and fuel cell bus initiative with key stakeholders.
- DOT through FTA is working in collaboration with DOE, EPA, DOD along with state, regional, and local government agencies (CEC, CARB, SCAQMD, NYSERDA) in the RD&D of advanced bus technologies.

Recent Progress

- Demonstrated 30-foot fuel cell hybrid bus with an automotive fuel cell system that achieved 11 miles per gasoline equivalent fuel efficiency.

Commercialization and Deployment Activities

- New York City Transit has ordered 325 series hybrid electric transit buses that are being delivered.
- Long Beach Transit has ordered 27 gasoline hybrid electric transit buses with added-on orders from other agencies potentially totaling 100.
- Demonstrations of parallel hybrid electric transit buses are underway and planned in Philadelphia, Seattle, Orange County, Minneapolis, and Austin.
- Demonstrations of seven Generation I fuel cell buses with the California Fuel Cell Partnership at AC Transit, Santa Clara VTA, and SunLine Transit.
- U.S. Heavy-Duty Fuel Cell Working Group established in 2002 with specific focus on buses. An International Fuel Cell Bus Workshop in Long Beach will facilitate the formation of an International Fuel Cell Bus Working Group.

Market Context

- Electric drive vehicle technology encompassing hybrid electric and fuel cell technologies are global in nature and highly competitive with major European and Asian companies actively pursuing RD&D.