Alternative Fuel Or Low Emission School Buses In North Carolina:

Draft Plan For Implementation

North Carolina State Board of Education
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Report Outline

1.0 Background

Senate Bill 953 (Session Law 1999-328), passed by the 1999 North Carolina General Assembly, requires the Department of Public Instruction (DPI), in conjunction with the Departments of Transportation (DOT), and Environment and Natural Resources (DENR), to develop a plan so that by the year 2004, 50% of new and replacement school buses, in counties with more than 100,000 population, be alternative fueled or low emission vehicles (LEV). This draft plan lays out options and steps toward implementation that can be identified at this time, projecting toward the year 2004.

DPI Transportation Services section chief Derek Graham and consultant Doug White attended the first joint meeting with the DOT and DENR on February 21, 2000. Initial discussions laid out a plan as to what responsibilities each agency was assigned by SB 953. A Technical Memorandum Number 1 was released that explained the key information concerning alternative fueled vehicles (industry standards, terms, etc.). The report was prepared by the Institute for Transportation Research and Education, under contract to DOT. A sub-committee was formed to reach consensus on a definition for low-emission vehicles (LEV). LEV is a key factor in DPI's plan to meet the requirements of the legislation. Doug White served on this sub-committee and met March 10 with other participants. A definition for the purposes of this plan was drafted and presented at the next full-committee meeting.

A follow-up meeting was hosted by DPI with the DOT and DENR on March 1 to clearly define the roles DOT and DENR would have in assisting the DPI to fulfill its requirements of SB 953. It was decided that the DPI would file a purchasing plan for school buses, but would adhere to the technical findings that all participating agencies agreed upon.

The DPI attended a second joint meeting on April 17 and received Technical Memorandum Number 2. This document provided information on the availability, cost and emissions of alternative fueled systems under consideration – battery electric, hybrid electric, hydrogen fuel cell, and natural gas. The report also addressed factors involved in retrofitting systems and construction of fueling facilities. As explained later, all of the fuel choices available in the transit bus market are not available in the school bus market.

A third joint meeting was held on June 29. Technical Memorandum Number 3 provided information to develop estimated emissions reductions and estimated capital and operating costs. These estimates were focused on the transit industry but a number of issues apply also to school buses.

This report has been shared with DOT and DENR staff that participated in the joint meetings.

The school bus industry in general is undergoing significant changes. There are only a few school bus manufacturers and each one offers primarily a single solution to states or school districts wishing to purchase alternative fueled or LEV buses.

This report presents a draft implementation plan, recognizing that the implementation of such a plan is contingent upon the appropriate funding. A discussion is contained herein of the relative costs associated with the top two fuel candidates – compressed natural gas and "clean-burning" diesel. Finally, a summary and appropriate next steps are identified.

2.0 Experience

The Public Schools of North Carolina have long had an interest in providing school transportation in a way that is least disruptive to the environment. Deviating from an all-gasoline school bus fleet statewide, the Department of Public Instruction piloted school buses with more fuel-efficient diesel engines as early as 1979. Starting in 1985, all replacement school buses purchased were diesel and the fleet became 100% diesel in 1999.

The State of North Carolina's experience in the use of an alternative fuel – namely compressed natural gas (CNG) – is concentrated in the Charlotte-Mecklenburg Schools. Two different projects were conducted using this fuel. In each case, the buses are returned to the main school bus terminal each evening and connected to a slow fill CNG station to be fueled for the following day.

In 1992, six gasoline school buses were converted to run on compressed natural gas (CNG) in the Charlotte-Mecklenburg Schools. The pilot program was sponsored by the Energy Division, NC Department of Commerce, in cooperation with the school system and Piedmont Natural Gas Company.

In 1996, eight transit-style school buses with OEM (Original Equipment Manufacturer) CNG engines were placed into service, again in the Charlotte-Mecklenburg Schools. The Energy Division again funded the CNG- related cost of the buses. At the same time, eight diesel buses of identical configuration were also placed in service. This has allowed for the comparison of the two fuel types over the past several years.

2.1 CNG Conversions

As noted in the Background, six gasoline engine school buses were converted to CNG in 1992. Three 1983 Ford and three 1984 International buses were converted for approximately $3,000 per bus. The Energy Division paid for the conversion and for the fueling station. Piedmont Natural Gas provided a compressor for the fueling station. These buses continued to operate using CNG until being replaced in the mid 90's.

2.2 CNG OEM (Original Equipment Manufacturer) Buses

In 1996, sixteen 78-passenger transit-style replacement school buses were placed in service in Charlotte-Mecklenburg. Eight of these were powered by CNG and eight by diesel using a Cummins 5.9L engine. The buses were manufactured by Thomas Built Buses of High Point, NC and are model Saf-T-Liner MVP (please see photo). An Energy Division grant covered the additional CNG engine beyond that cost of a standard diesel engine.

Cost of 78-Passenger diesel school bus: $53,908
Cost of 78-Passenger CNG bus: $69,776

The following table summarizes the experience with these buses since they were placed in service in 1996:

Fuel Type	Labor Cost	Parts	Fuel	Life Miles	Fuel $/Mile	Total $/Mile
CNG	$3,266	$9,766	$4,069	41,980	$0.0969	$0.41
Diesel	$3,788	$4,900	$4,546	47,008	$0.0967	$0.28

These are average lifetime costs and miles through the 2000 school year for the eight CNG buses and the eight diesel buses. As the chart illustrates, repair parts for the eight CNG buses averaged virtually double that of the diesel buses. This additional cost is partly due to the extra components required of the CNG fuel system. Items such as oxygen sensors ($278) pressure regulators ($501), ignition modules ($803) and leak detection alarms ($700) are very expensive to replace. Until CNG vehicles become more common, the high cost of replacement parts will continue to be a drawback. Total cost per mile clearly represents the additional cost associated with CNG – 46% more.

3.0 Vendor Options for School Bus Purchases

There are approximately 13,000 buses operating in North Carolina transporting some 700,000 pupils and traveling over 800,000 miles daily. The typical school bus is referred to in the industry as either "conventional-style" or "transit-style." The conventional bus is comprised of a truck-like chassis whereupon a bus body is mounted. The two pieces, chassis and body, are manufactured by different companies. This is the predominate style of bus operating in this state and comprises about 97% of the fleet. The transit-style school bus is very similar in design to public transportation buses. The bus is wholly manufactured by one company, and the chassis and body are an integrated unit. The engine is usually mounted in the rear of the bus and the front of the bus is flat. Transit style school buses offer advantages in terms of student safety. The driver is at the very front of the vehicle and much less likely to miss seeing a student crossing (or falling) in front of the bus. The transit style buses are, however, significantly more expensive. In fact, during the last two years only 38 transit-style buses have been purchased in North Carolina because of the additional cost. Transit style buses only comprise 3% of the state bus fleet. North Carolina started purchasing transit-style buses in 1996 and there are about 350 operating at this time.

New and replacement school buses in North Carolina are purchased from a state contract administered and developed by the Department of Public Instruction and the Division of

Purchase & Contract, North Carolina Department of Administration. Traditionally, a bid has been issued for a conventional school bus chassis, conventional school bus body and a complete unit transit-style school bus. Historically, conventional chassis and bodies could be mixed and matched among all potential bidders as these were all separate companies.

In recent years, however, one school bus body company, AmTran Corporation, was acquired by a major chassis supplier, Navistar International Corporation. Even more recently, another major body company, Thomas Built Buses, Inc., was acquired by another major chassis supplier, Freightliner Corporation. This has led to a situation where in coming years, the Thomas conventional school bus body will only be available on the Freightliner chassis and the AmTran body will only be available on the International chassis. A third body company, Blue Bird Body Company, also builds conventional school buses. The company currently offers a Chevrolet/GMC or International chassis but a long term chassis supplier is unclear at this time due to the mergers mentioned above. Blue Bird has been recently acquired by Henlys Group PLC, a Great Britain bus body and coach builder.

Blue Bird, AmTran, and Thomas all make integrated transit-style school buses, similar to the ones described previously in use in Charlotte.

3.1 Navistar International Transportation Corporation/AmTran Corporation

International or AmTran do not currently offer a CNG product. International's initiative in clean air has recently focused on providing a different low emission school bus solution.

The focus of this effort is on "Green Diesel Technology." According to information from International, green diesel results in emissions that are lower than current compressed natural gas emissions. Two key elements enable this new level of diesel emissions performance: ultra-low sulfur diesel fuel (actually dyed green in color) and a continuous regenerative particulate trap (CRT). The proposed fuel contains less than fifteen parts per million (PPM) of sulfur compared to currently mandated 500 PPM in federally qualified diesel fuel. This huge 97% reduction in sulfur greatly reduces the production of particulate matter in the diesel combustion process. After combustion, the particulate trap absorbs nearly all of the remaining particulate content. Hydrocarbons are also eliminated to almost a zero level.

As International/AmTran is fully convinced that Green Diesel Technology is the most practical solution to future emission standards, the companies do not plan to offer a CNG product in the future. While the technology currently exists for these new diesel engines, the special fuel does not. Refinery equipment to reduce the sulfur content down to the level required by these engines is very scarce. Meanwhile, a field test is currently under way using school buses fueled by green diesel in San Diego, California.

3.2 Freightliner Corporation/Thomas Built Buses, Inc.

Thomas Built Buses offers a CNG engine that will meet the requirements of the legislation. The Saf-T-Liner ER (Engine Rear) transit style bus may be equipped with either a Cummins 6CG 250-HP or a John Deere 8.1L 250-HP engine. The transit-style may also be equipped with a Cummins ISB 215-HP LEV diesel engine. Freightliner currently has no plans to offer a CNG engine in a conventional school bus chassis but does offer the Cummins LEV diesel. A LEV diesel from the Caterpillar engine company will be available by the third quarter of 2000.

3.3 Blue Bird Body Company

Blue Bird also offers a CNG engine in their transit-style product. The All-American RE (Rear Engine) may be equipped with either a John Deere 8.1L 250-HP, Cummins 5.9L 195-HP or a Hercules GTA 5.6L 190-HP engine. The CNG option offered by Blue Bird is available only in the transit style school bus. Their option for conventional school buses, however, is based on liquid propane gas (LPG). This option is a *conversion* from a gasoline engine which, under the legislation, is not considered to be a new vehicle. Therefore, this is not an alternative for consideration. Furthermore, experience in Texas school districts, which made significant investment in LPG technology, makes this fuel option less than favorable.

4.0 Implementation of the 50% Mandate

Implementation of this plan is very much contingent on the availability of resources. The plan, according to the legislation, calls for the purchase of at least 50% of all new and replacement school buses in the alternative fueled (CNG) or LEV category. According to the legislation, this applies to all buses for use in counties of 100,000 or more population of which there are twenty-three (see Table). All the municipalities except Jacksonville (Onslow) and Goldboro (Wayne) have some access to natural gas. Two cities, Lexington and Monroe, actually resell natural gas to the public and fuel rates would be higher in these areas. Some of the smaller municipalities such as Smithfield (Johnston) may not have gas lines located where a fuel station would be practical. Because of the additional infrastructure requirements, the Department of Public Instruction – charged with the implementation of this plan - would likely concentrate on the counties that operate and receive the most buses. Instead of placing the buses in the some twenty-one counties that have access to CNG pipelines, the buses would be concentrated in Buncombe (Asheville), Cumberland (Fayetteville), Durham, Guilford (Greensboro), Charlotte/Mecklenburg, and Wake (Raleigh) counties. By limiting the buses to these six counties, the additional cost factors associated with this technology will be greatly reduced. Regardless of the fuel strategy, it would be most cost effective to develop infrastructure in counties where buses are being added to the fleet than those where one or two new vehicles may be acquired per year. So, even if there are some counties with 100,000 or more population that do not receive any alternative fueled or LEV buses, the overall statewide procurement would equal at least 50% of their required number.

County	City	CNG Available	Projected Buses	Projected CNG	Actual CNG
Alamance	**Burlington**	**Yes**	**6**	**3**	**0**
Buncombe	Asheville	Yes	10	5	8
Cabarrus	Concord	Yes	13	7	0
Catawba	Hickory	Yes	2	1	0
Cumberland	Fayetteville	Yes	15	7	15
Davidson	Lexington	Yes	6	3	0
Durham	Durham	Yes	26	13	26
Forsyth	Win. Salem	Yes	14	7	0
Gaston	Gastonia	Yes	5	3	0

Guilford	Greensboro	Yes	32	16	32
Iredell	Statesville	Yes	11	5	0
Johnston	Smithfield	Limited	12	6	0
Mecklenburg	Charlotte	Yes	32	16	32
New Hanover	Wilmington	Yes	11	5	0
Onslow	Jacksonville	No	----	----	----
Orange	Chapel Hill	Yes	8	4	0
Pitt	Greenville	Yes	9	5	0
Randolph	Asheboro	Yes	6	3	0
Robeson	Lumberton	Yes	14	7	0
Rowan	Salisbury	Yes	12	6	0
Union	Monroe	Yes	8	4	0
Wake	Raleigh	Yes	26	13	26
Wayne	Goldsboro	No	----	----	----
State Total			**278**	**139**	**139**

4.1 Timing

Typically, the state contract for school buses begins around November and lasts for a full year. Following the appropriation by the General Assembly in the summer, purchase orders are issued for replacement school buses by the Department of Public Instruction in August/September. This provides the advantage of purchasing from the end of the contract in order to retain the best pricing. The buses that are ordered at this time are not delivered until early the following year (usually January-May).

In compliance with HB 953, subject to the availability of funds, DPI would place the first bus order under this act in August 2004. These would be 2005 model buses.

School bus specifications are reviewed each year by a committee made up from local school employees and representatives from State Purchase and Contract, Department of Motor Vehicles and the DPI. The committee will consider making LEV diesel the standard engine, once it is available from all competing manufacturers. Therefore, the requirements of SB 953 may be met before the 2004-2005 school year.

5.0 Cost – CNG

There are numerous issues to address if CNG buses are used in this plan. The additional expense, starting with the purchase and following the bus through its life cycle, is significant.

5.1 Initial Purchase

Based on the availability of product from the manufacturers, the purchase of CNG buses would be costly. This cost is not only due to the additional expense of the CNG system but also the increased cost of a transit-style bus versus a conventional bus.

As a CNG conventional bus is not currently on the market, the state would have to substitute transit-style buses. The current cost of a 78-passenger transit-style bus is some $19,000 more than a 66-passenger conventional bus. Although the capacity is more for the transit-style, the cost increase is not in proportion favorably to any advantages a county would gain by that increased capacity.

Based on estimates from Thomas Built Buses, the cost of a 78-passenger CNG bus is $34,000 more than a comparable 78-passenger diesel bus. This estimate is based on a four-tank CNG system, which equates to about 45 gallons of diesel fuel. The fuel tank capacity for current diesel buses is 60 gallons. The two cost factors, transit-style over conventional coupled with CNG over diesel, would equal a $53,000 increase per bus. **This is a 114% increase in the purchase price of a North Carolina school bus.**

DPI is currently replacing school buses based on life mileage of 160,000 or 20 years. The current projection for the number of buses to be replaced in the 2004-05 school year is around 600 buses. Of this number, about 300 buses would be placed in the 23 counties with populations over 100,000. This would mean that 150 buses would be purchased to meet the requirements of HB 953. Using the cost increase of $53,000 per bus, the additional funds needed to purchase CNG buses would be over $7.9 million for the 2004-05 school year. This cost increase would continue for succeeding years as future bus purchases should remain in the 400-600 unit range. If additional funds are not provided to address this cost increase, the buses replaced for the 2004-05 school year would have to be reduced from the projected 612 down to 442.

5.2 Infrastructure

A greater cost than the bus purchase could be the physical structure needed to fuel the buses. The Charlotte CNG buses are fueled each evening after each bus has operated for the day. The fuel station is referred to as a slow-fill CNG in that it takes 3-4 hours to refill each bus. This is a much less expensive system than a quick-fill station, which can fill a vehicle in minutes. In the slow-fill system, each bus must have a dedicated pump and several pumps share one compressor.

Based on cost estimates from Piedmont Natural Gas Company, the equipment for a slow fill fueling station costs about $5,000 per vehicle. Due to this significant facility cost, it would be imperative to place CNG buses in counties that either have a fuel station in place (i.e., Charlotte) or concentrate the buses in a few counties. As stated in Section 4.0, it would be financially burdensome to require an investment in CNG infrastructure for only a few buses. It must be noted that, according to Public School Law 115C-249(e), the county boards of education are responsible for providing “adequate buildings and equipment for the storage and maintenance of all school buses.” Therefore, the cost associated with fueling CNG buses would ultimately have to be absorbed by local county government.

5.3 Routing/Fueling

CNG buses have limited range – about 38% of the range of diesel buses. While the range of a CNG bus is about 150 miles, a diesel bus has a range of over 400 miles and can go two-three days before refueling. This limitation in range, coupled with the fact that it is a 78-passenger capacity, must be considered in placing the bus on a route. While areas like Charlotte (high pupil density) may be conducive to a 78-passenger CNG bus, more rural counties may be hard pressed to find a route compatible to the capacity.

The counties currently operate a fuel truck fleet to facilitate the fueling of diesel buses. Refueling is typically performed mid-day when the buses are staged at the schools. This staging of buses at different locations around the county is critical to minimize both driver deadhead time and student ride times. This remote fueling is not possible with the

CNG bus, as it must be returned to the slow-fill station each evening. There are no options for staging the bus elsewhere, so the driver must begin and end the route from the fuel station.

5.4 Maintenance

As stated in Section 2.2, the average cost of parts for the Charlotte CNG buses is almost double that of the diesel buses. The unique parts inherent with the CNG system are not only costly, but sometimes inaccessible. Downtime also has to be factored into the equation when assessing the cost-effectiveness of CNG. According to maintenance records at Charlotte-Mecklenburg, the CNG buses have been out of service a total of 184 days for the 1999-2000 school year. This factor represents a 13% downtime rate.

5.5 Funding Assistance

Both CNG efforts in Charlotte have been totally funded through grants from the State Energy Division. Either an increased state appropriation or outside grants will be necessary to avoid a reduction in replacement buses (See Section 5.1) and to aide local boards of education in constructing fuel facilities.

6.0 Costs – Diesel LEV (Low Emission Vehicle)

In 1990, Congress updated the Clean Air Act, the nation's basic air quality law, and created the Clean Fuel Fleet Vehicle program (CFFV). The CFFV program helps to ensure compliance of the country's 22 smoggiest areas (none in NC) with the EPA's national ambient air quality standard for ozone. The CFFV rules do not require the use of alternate fuels, but do set more stringent emission performance levels for certain vehicles. Vehicles that comply are referred to as Low Emission Vehicles (LEV). The latest generation of diesel engines that currently qualify as LEV under the program can equal CNG emission levels and the cost factors are much more appealing. According to the engine manufacturers, diesel technology will meet all EPA emission standards well before 2004.

The following chart contains data published by International showing how the latest diesel technology measures up to the 2004 EPA exhaust emission standards. NOx is oxides of nitrogen, PM is particulate matter and NMHC is non-methane hydrocarbons. The numbers represent grams per horsepower-hour.

	NOx	PM	NMHC
EPA 2004 Standard	2.0	0.1	0.5
Typical Diesel	3.8	.06	0.5
Diesel LEV	3.2	.005	0

Although diesel does not yet meet the NOx standard, neither does CNG. A typical CNG engine is currently rated at 3.2 NOx, comparable to diesel LEV. As stated before, the engine manufacturers will have NOx for both fuels down to 2.0 by 2004.

6.1 Initial Purchase

Using the same bus purchase projections as in Section 5.1, the estimated additional cost to buy diesel LEV buses would be $225,000. This is based on the purchase of 150 buses and estimated additional engine cost of $1,500 per bus. This cost estimate was supplied by Thomas Built Buses for the LEV version of the Cummins ISB engine. This additional cost could be absorbed within the DPI bus appropriation by ordering five less buses for the 2004-05 school year.

6.2 Infrastructure

Likewise with facilities, the financial impact of diesel LEV is minimal. Even if ultra low-sulfur or "green" diesel is used, all diesel buses would be able to use the fuel. No additional storage or specialized pumping system would be required as with CNG. However, since it is more expensive than the low sulfur fuel currently used, separate storage facilities might be needed.

6.3 Routing/Fueling

Considering that ultra low-sulfur diesel can be transported and dispensed as current diesel fuel, there are no additional cost factors involved in this area except as indicated in 6.2 above.

6.4 Maintenance

It is unknown at this time if the use of ultra low-sulfur diesel would cause increased (or decreased) maintenance of diesel engines.

6.5 Funding Assistance from State/Federal Grants

The projected increase in cost of diesel LEV could be absorbed in the state bus purchases but grant money will be explored.

7.0 Next steps

DPI suggests a close monitoring of industry in the next two years before making any final decisions on the type of buses to purchase. If the same progress is made in those two years as has been made the past two, we should see some dramatic developments from the engine manufacturers. If CNG becomes more cost effective, it should be given every opportunity for expansion to other counties. On the diesel side, the engine companies have all confidence that their LEV efforts will produce a product that meets or exceeds future EPA clean air standards and is affordable for the customer.