Executive Summary

By the request of Cache Valley Transit District (CVTD) a study was performed comparing the levels of carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_X) discharged in the emissions of a conventional diesel bus, a hybrid diesel-electric bus and a compressed natural gas (CNG) bus - all three being new models equipped with the latest in emissions-control technology for their respective engine types.

The study was conducted over the first half of 2011, outside of a laboratory setting using on-board instrumentation to measure and record levels of in-tailpipe, air pollutant output on a regular bus route with changing grades and frequent stops (CVTD Route #4) and also on a flatter more continuous semirural bus route (CVTD Franklin County Connection route). In addition to bus testing, a sample of personal automobiles driven along the examined bus routes was tested and included in the study in order to help answer the question, "*how many bus passengers would be required to produce a net reduction in the overall emissions to the local air shed?"*

The testing of the buses was conducted on a randomized basis in no particular order with respect to bus type, day of week or time of day. The emissions data collected was processed and displayed for comparative purposes in units of grams per mile. The following table displays the results from the testing. (Note that "SV" represents the personal automobile sample and "(ID)" indicates the data are for the Franklin County Connection route).

	CNG	Diesel (Rt. 4)	Diesel (ID)	Hybrid (Rt. 4)	Hybrid (ID)	SV
CO2 (g/mile)	447.9±26.9	127.6±10.2	175.8±3.55	246.6±11.1	120.6±2.96	743.9±12.3
CO (g/mile)	0.7321±0.268	0.0074±0.003	0.0035±0.001	0.0251±0.134	0.9986±0.132	32.56±2.17
HC (g/mile)	0.0752±0.007	0.0144±0.002	0.0583±0.004	0.6216±0.026	0.6010±0.068	5.277±0.175
NOX (g/mile)	0.0247±0.016	0.0004±0.000	0.0163±0.002	0.3494±0.007	0.0680±0.004	0.4118±0.051

As can be seen in the table above, the hybrid bus was outperformed by both the conventional diesel and the CNG in every area except the carbon dioxide output of the CNG bus. This was not expected and it is suggested that this could be due to design conditions where the hybrid bus burns more diesel fuel per engine volume unit than the conventional diesel bus, indicating that the hybrid's engine is working harder, which would explain the discrepancy. The CNG and the conventional diesel buses performed very similarly but the conventional diesel proved to be the best performing in all areas. It should be noted that it is suspected that a diesel particulate filter (DPF) regeneration occurred during one of the hybrid runs on the Franklin County Connection route, based on a spike in pollutant emission levels over a 20-minute segment of that run. This could account for slightly higher values in all pollutant areas except for NO_X on the Hybrid (ID) figures. It is purposed that further research be done to determine the contribution of DPF regenerations in overall emissions performance.

Several questions were answered in this study, including the following question, which is also mentioned above, "*how many bus passengers would be required to produce a net reduction in the overall emissions to the local air shed?"* The report explains that the answer to this question depends on which make and model of vehicle is being considered. As displayed in the table above, there were large differences in emissions between the different personal vehicles examined. The answer may more importantly depend on which air-pollutant is the main concern. For example, the Pontiac G6 was found to produce the lowest levels of NO_X, but the highest levels of HC. However, considering the averages of all the vehicles combined, it would only take one person to choose to ride the bus over driving a car to reduce the net air pollution in Cache Valley. This can be attributed to the Cummins Aftertreatment System (CAS) which produces near-zero emissions from the new CVTD buses.

This study also reports on how the bus' emissions compare to Environmental Protection Agency's (EPA) emissions standards for urban buses. The following table, taken from the report, shows this comparison:

	Standard (g/mile)	Diesel (high value)	Hybrid (high value)
CO	50.38	0.0074±0.003	0.9986±0.132
NOX	0.65	0.0163±0.002	0.3494±0.007
NMHC	0.455	0.0583±0.004	0.6216±0.026

As displayed by the table above, the conventional diesel bus was well below the EPA standards in all three areas. The hybrid diesel-electric buses were well within the standards for CO and NO_X but slightly exceeded the non-methane hydrocarbon (NMHC) standard. However, since an approximate conversion factor was used, there is an unknown margin of error in the EPA standard. Therefore the hybrid diesel-electric bus may in fact be under the EPA standard. (Note that a full description of the approximate conversion factor can be found in the "EPA Urban Bus Emissions Standards Information" section of the report).

In conclusion, it was found that the new CVTD buses greatly outperformed older buses in similar studies – to the point that it would only take one person in Cache Valley to choose to ride one of the new buses, in order to reduce air-pollutant emissions locally. With public support, these new buses have the potential to help mitigate the air quality problems faced by Cache Valley that are related to vehicle emissions.

Please see the full report for further details.