ENVIRONMENT & ENERGY COMMISSION

City of Columbia & County of Boone

May 27, 2014

Mayor McDavid and Council Members,

The Environment and Energy Commission submits the following report on alternative transportation fuels to inform policies regarding City fleet vehicles. This report is submitted pursuant to request of Councilperson Ian Thomas made at the September 7, 2013 Council meeting. The content of the report, as confirmed by exchange of message between Councilman Thomas and the Energy and Environment Commission, is directed to be "*. . . To compare the current and future viability, the environmental impact and the financial cost of various vehicle fuel technologies and include diesel, biodiesel, compressed natural gas, and renewable-sourced electricity. The purpose of this report would be to guide a future policy of city fleet vehicles.*"

Executive Summary

The adoption of efficient fuels, new technologies, and effective transportation policies offer opportunities to reduce fuel costs for the City fleet and reduce environmental impacts within the City of Columbia and beyond. While there is uncertainty in forecasting future fuel prices and environmental consequences associated with each and every fuel type, prudent transportation system policies and an investment in a diversified fleet that employs suitable technologies will reduce overall fuel consumption, reduce fuel costs, reduce the City's total greenhouse gas emissions and improve local environmental quality.

This report examines five alternative fuel types presently available for some or all types of vehicles operated by the City of Columbia, including: hybrid electric vehicles (HEVs); plug-in hybrid electric vehicles (PHEVs); all-electric vehicles (EVs); Diesel/biodiesel vehicles; and compressed natural gas (CNG) vehicles. Possible reductions of greenhouse gas emissions and opportunities to reduce fuel usage, fuel costs, and costs of ownership are discussed for each fuel type. This report also discusses the significant economic savings and reduced environmental impacts of a widely applied and enforced no-idling policy. This report does not attempt to calculate tailpipe or greenhouse emissions for individual vehicles or for the fleet. This report also does not attempt to forecast future fuel prices; however, for a greater understanding of the recent patterns of fuel costs, a table of historic fuel prices is attached.

Recommendations

The Environment and Energy Commission offers four major recommendations:

Recommendation 1: The EEC strongly recommends choosing hybrid vehicles of all types when replacing old or buying new fleet vehicles. Increasing the number of hybrid vehicles in the fleet significantly reduces fuel use and cost, decreases greenhouse gas emissions and reduces impacts on local air quality. Investment in all-electric vehicles (EVs) and/or plug-in electric hybrid vehicles (PHEVs) should be seriously considered for fleet vehicles used for daily local trips. Photovoltaics (PV) should be installed to offset the greenhouse gas produced by using coal as the primary fuel for generating electricity to charge PHEVs and EVs.

Recommendation 2: The EEC recommends significantly increasing the use of biodiesel in diesel fleet vehicles. All diesel equipment manufacturers approve biodiesel blends up to 5%; the majority of manufacturers approve blends of 20% in current vehicle offerings. One hundred percent biodiesel reduces greenhouse gas emissions 76% compared to average petroleum diesel. Although the City currently pays nominally more for biodiesel, there may be opportunity for cost savings if the City were to revisit their contracting options. Additionally, most biodiesel produced in Missouri uses locally produced soybean oil. Therefore, most of the money stays in the region and supports our local economies.

Recommendation 3: The EEC finds that there is no convincing environmental reason to add more compressed natural gas (CNG) fueled vehicles to the City fleet at this time. The cost of CNG is significantly lower than gasoline at the present, but the cost of electricity for fuel is substantially below that of CNG. Recent research indicates that CNG is about equivalent to gasoline in terms of lifecycle greenhouse gas emissions from production to final use. Cost forecasts for natural gas may change significantly in the future as shipping liquefied natural gas overseas develops.

Recommendation 4: The EEC recommends enforcing the City's existing "no-idle" policy for vehicle use. Decreased vehicle usage, increased fuel efficiency through smaller, lighter vehicles, and other transportation policies all promise to reduce overall fuel consumption. Reduced fuel consumption offers definite and direct means to reduce both costs and environmental damage.

Review of Alternative Fuels

Creating a diverse fleet not reliant on a single dominant fuel type will allow the city to maximize efficiency and be resilient to fuel markets outside of local control. The City fleet is composed of approximately 1,000 vehicles of various types including buses, cars, vans, and trucks. Most vehicles have gasoline or diesel engines, although the City has also acquired a small number of hybrid vehicles and is currently acquiring some vehicles powered by CNG.

The purchase of new and replacement fleet vehicles presents an opportunity to select models that reduce fuel use and save money on fuel and cost of ownership; reduce tailpipe emissions and improve local air quality; and reduce the greenhouse gas emissions beyond the county line. In this section we present our research into five alternative fuel vehicles: hybrid electric vehicles (HEVs); plug-in hybrid electric vehicles (PHEVs); all-electric vehicles (EVs); diesel/biodiesel vehicles; and compressed natural gas (CNG) vehicles.

Hybrid Electric Vehicles (HEVs), Plug-in Electric Vehicles (PEVs) and All-Electric Vehicles (EVs)

Hybrid electric vehicles (HEVs) are now available for both gas and diesel engines in a wide range of applications from compact cars to trucks. Increased average fuel mileage per gallon decreases tailpipe emissions and reduces greenhouse gases. HEVs have lower five-year ownership costs, lower fuel costs, and higher resale prices than conventional vehicles, all of which justify higher purchase costs (Gilmore and Lave, 2013). By purchasing more hybrid vehicles as Columbia replaces older vehicles, a significant reduction in fuel use, cost, and greenhouse gas production can be achieved. The economic impact of this potential saving over the life cycle of City fleet vehicles should be carefully evaluated.

Plug-in hybrid electric vehicles (PHEVs) offer drive time on a charged battery before they must switch to standard hybrid mode. For local trips, a daily battery charge would likely cover all or most daily mileage. Payback for PHEVs is similar or better than payback for conventional vehicles (Al-Alawi and Bradley, 2013). Increased average fuel mileage per gallon of fuel decreases tailpipe emissions and reduces greenhouse gases.

All-electric vehicles (EVs) use a battery to store the electrical energy that powers the motor. Both heavy-duty and light-duty EVs are commercially available (U.S. DOE, " All-Electric Vehicles" 2013). EVs are typically more expensive than similar conventional and hybrid vehicles, but some cost can be recovered through fuel savings and other incentives. According to the U.S. DOE fuel economy website (www.fueleconomy.gov), moderately priced EVs can travel between 62 to 103 miles per charge, depending on the model. EVs have no tailpipe emissions that contribute pollutants that degrade local air quality.

Sources of electricity for charging PEHVs and EVs affect the calculation of greenhouse gas emissions and vary geographically (Dolan, Le, and Taufik, 2012). Columbia Water and Light and Boone Electric Co-op purchase electricity primarily produced by coal-fired power plants; 91% of electricity purchased by Columbia Water and Light in fiscal year 2013 was sourced from coal-fired plants. Therefore, using electricity for plug-in electric hybrid or all-electric vehicle fuel will result in a higher greenhouse gas calculation in Columbia, MO, than in a community that generates energy from renewable sources such as solar. To match the greenhouse gas reduction advantage of HEVs, the proportion of local electricity produced by coal should be 78% or less
(based upon calculations from data in Al-Alawi and Bradley, 2013).

One way to take advantage of both reduced fuel costs and low tailpipe emissions offered by PEHVs and EVs is to offset potentially high greenhouse gas production with an installation of photovoltaic (PV) units for electricity production. Money saved on fuel by using PHEVs and EVs should be used to cover costs of such investment, which should then in turn, be paid back via savings in fuel cost. About one kW of PV panels per plug-in hybrid or electric vehicle will conserve more greenhouse gas emissions than a regular hybrid. Three or four kW of PV per vehicle will eliminate most of the greenhouse gas produced annually. Electricity is the lowest cost fuel; it achieves about 1.5 times the mileage per dollar spent compared to dollars spent on gasoline or diesel (Figure 1). Increasing efficiency and falling prices in PV technology will result in short payback for these types of projects.

Hybrid Vehicle Case Study: Scenario 1 Replace Community Development SUV (#901) with a PHEV or a new efficient vehicle: The City of Auburn Hills, Michigan found that replacing a city SUV with a hybrid SUV of similar capacity saved a total of $770 per year per vehicle, including $743 in fuel costs, for a vehicle that is used an average of 26 miles per day (about 6760 miles per year). Greenhouse gas emissions were reduced by 1.7 tons or 64%. (City of Auburn Hills, 2013) If, for example, 20 such vehicles were driven 10,000 miles per year, the savings would be about $21,982 and the greenhouse gas emissions would be reduced by 50.3 tons.

Diesel/Biodiesel Vehicles

Diesel engines are up to 30% more fuel efficient than gasoline engines (U.S. DOE Diesel Vehicles, 2014). This results in fuel cost savings on fuel of a few hundred dollars per vehicle per year over comparable gasoline models. Additionally, diesels have lower five-year ownership costs, lower fuel costs,. and higher resale prices than gasoline vehicles (Gilmore and Lave, 2013). Reliance upon diesel fueled vehicles vs. gasoline thus results in a modest reduction in total greenhouse gas emissions.

Biodiesel is a renewable alternative fuel for petroleum diesel most often implemented in blends with diesel fuel. The use of biodiesel does not require vehicle replacement. All diesel equipment manufacturers approve biodiesel blends up to 5%. The majority of diesel equipment manufacturers approve blends of biodiesel up to 20% in current vehicle offerings (NBB, 2014). Manufacturers that do not yet approve B20 include light duty vehicles manufactured by Audi, BMW and Mercedes. Tailpipe emissions of biodiesel have been found to contain less hydrocarbons and particulate matter than regular diesel; reduction in these pollutants increases with increased biodiesel blends (McCormick et al., 2006).

One hundred percent biodiesel produces 76.4% less greenhouse gas emissions than produced by average petroleum diesel (Pradhan, 2012). City fleet diesel vehicles currently use B2 biodiesel, which is 98% diesel fuel and 2% biodiesel, resulting in a 1.7% reduction in greenhouse gas emission relative to average diesel. According to Fleet Operations Manager, Eric Evans, the City's cost is $0.01 increase in cost per gallon for each 1% biodiesel blended with petroleum diesel. Although the City currently pays nominally more for biodiesel, there may be opportunity for cost savings if the City were to revisit their contracting options to see if they can negotiate a better price from the terminal and reduce the rack markup. The national average wholesale cost of biodiesel is less than the wholesale cost of diesel, and retail prices for B20 are competitive. (US DOE Alternative Fuel Price Reports)

Additionally, most biodiesel currently produced in Missouri uses locally produced soybean oil. The truck driver that delivers to the terminal, the biodiesel producer, and the farmer all live and work in central Missouri. When the city buys biodiesel, some of that money circulates in the local economy.

Compressed Natural Gas (CNG) Vehicles

The current market price of natural gas and incentives offered up by CNG industry to the City offers a financial benefit by replacing some fleet vehicles with CNG-powered vehicles. However, long-term financial benefit is uncertain. Cost forecasts for natural gas may change significantly in the future as shipping liquefied natural gas overseas develops. It is reasonable to include CNG vehicles in a diverse City fleet but it is risky to convert the entire fleet to any one fuel. Doing so prevents the City from being flexible and resilient to changes in fuel technologies and vehicle markets, fuel prices and supplies, and other as yet unforeseen issues.

Recent studies (Brandt et al., 2014; Jackson et al, 2014) raise serious questions about low greenhouse gas emission calculations previously attributed to natural gas; leaking in extraction and distribution systems may contribute more natural gas to the atmosphere than previously calculated. The main constituent of natural gas is methane, a compound whose potent "greenhouse" effect is approximately twenty-five times greater than that of carbon dioxide. A comparatively small amount of methane emitted to the atmosphere is therefore contributes more potential warming of the atmosphere than the same volume of carbon dioxide resulting as an unavoidable by-product of burning any fossil fuel. Incidental leakages may double estimates of the greenhouse gas burden of natural gas use and suggest there may be a small environmental advantage to CNG over petroleum fuel.

While our community and local environment may not seem to be greatly affected by the expanding natural gas industry, many citizens in this community are concerned with the process of hydraulic fracturing (fracking) by which this fuel is extracted. Fracking has been attributed with hydrologic damage (Lange, et al., 2013), seismic activity (Baisch, 2013), and degraded air and environmental quality in communities where fracking is present (Field, Soltis, Murphy, 2014). Hydraulic fracturing is associated with as much as thirty percent of U.S. natural gas production today and is projected to increase from 5 trillion cubic feet (tcf) in 2010 to 13.6 tcf in 2020. Private and governmental efforts are presently under way to promote increased international sales of U.S.-produced liquefied natural gas. Success in these efforts may exert upward pressure upon natural gas prices.

Some say that "natural gas is a potential 'bridge fuel' during transition to a decarbonized energy system" (Brandt et al., 2014). For this and economic reasons, CNG has been seen by some as a generally attractive alternative to gasoline and diesel fuel for vehicles. Communities like Boulder, Colorado (Boulder, 2014) are using CNG to move away from petroleum and plan to move toward all-renewable electricity. If this planning was adopted in Columbia, our community would have the greater advantage of having secured local control of energy generation and use – Columbia already owns its own energy utility, Boulder does not. Transitioning to electric vehicles charged by photovoltaics is a better bridge to a decarbonized energy system.

At present prices, CNG costs less per mile driven than either gasoline or diesel fuel. CNG vehicles are credited with the local use benefit of lower tailpipe emissions and improved local air quality. However, like electricity, the calculation of greenhouse gas emissions for CNG will depend on the geography of energy extraction and generation. Unlike electricity, which can be generated locally using solar or a variety of fuels, the generation and distribution (and associated resulting unforeseen costs) of natural gas are not under local control.

While there may be a cost advantage to moving part of the fleet to CNG, which has been done, there is no convincing environmental reason to add more compressed natural gas (CNG) fueled vehicles to the City fleet at this time. The cost of compressed natural gas is significantly lower than gasoline at the present, however, the cost of electricity for fuel is substantially below that of compressed natural gas. Just considering fuel costs, electricity is, and is likely to continue to be, the cheapest fuel. Cost forecasts for natural gas may change significantly in the future if shipping liquefied natural gas overseas develops.

Cost of Fuel

The important cost data is the bid price we receive for fuel. The Appendix contains a history of national average costs (U.S. DOE, Clean Cities Alternative Fuels Price Report) and provides an approximation of the relative costs of various fuels and some idea of the price fluctuation. Future prices are not determined by past prices. Two potential future changes are likely at some point: 1) sale of liquified natural gas in international markets would drive U.S. natural gas price up toward the international market price which is substantially higher; and 2) a carbon (dioxide) tax or regulation on existing coal-fired electric generators would increase the cost of coal-fired electricity.

City Transportation System

The City of Columbia vehicle fleet comprises approximately 1,000 vehicles of various types including buses, cars, vans, and trucks of varying weight and capacity. Most vehicles are gasoline or diesel fueled although the City has also acquired a small number of hybrid units and is acquiring some vehicles powered by CNG. Diesel fuel accounts for approximately seventy percent of more than $3.5 million spent on fuel in 2013.

The consideration of transportation policies is best supported by evaluating the entire city transportation system as a whole rather than its composite elements which are interdependent. Economic cost and environmental impact are best represented within a broad conception of this system that includes both the full life vehicle cycle from specification to acquisition to use to disposal and also the full fuel cycle from resource extraction to transmission from origin to consumption to disposal of waste products. Maintenance practices throughout the system affect both economic cost and environmental burden. Net economic cost and overall carbon footprint are products of characteristics of the entire transportation system. In those this systems, choices made to address local-scale economic costs have wide-scale consequences. Likewise, employing a variety of fuel and technology options keeps Columbia and its fleet resilient and adaptable to changes.

Idling Reduction and No-Idle Policy

Enforcement of the City's existing no-idling policy offers an immediate opportunity to reduce fuel consumption, save money, and improve local air quality. According to the US Department of Energy (US DOE, "Idling pushes profits out the tailpipe" March 2013), "Idling a heavy-duty truck consumes an average of 0.8 gallon of fuel per hour." If one heavy duty truck idles for 3 hours a day, 5 days a week, it wastes $2,496 in fuel per year. Using an idling cost calculator provided by Argonne National Laboratory (Argonne), a medium-duty truck, idling 3 hours a day, seven days a week wastes between $1,996.80 per year (idling at 800 RPM, AC off) to $2,267.20 (1200 RPM, AC on

50%).

The implementation of idling reduction devices where applicable also results in immediate fuel cost savings and reduced tailpipe emissions. For utility trucks that need power for working purposes, several idle-reduction technologies exist, (US DOE "Medium-Duty Vehicle Idle Reduction Strategies." March 2014) including auxiliary power systems. The costs of implementing these technologies are recouped by the savings in fuel costs. The Argonne calculator also provides fields to calculate costs related to idling reduction devices and payback time. The Dallas Police Department (US DOE "Case Studies – Dallas Police) has successfully implemented such a policy.

Conclusion

Considering the information reviewed, the EEC offers four recommendations:

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Appendix

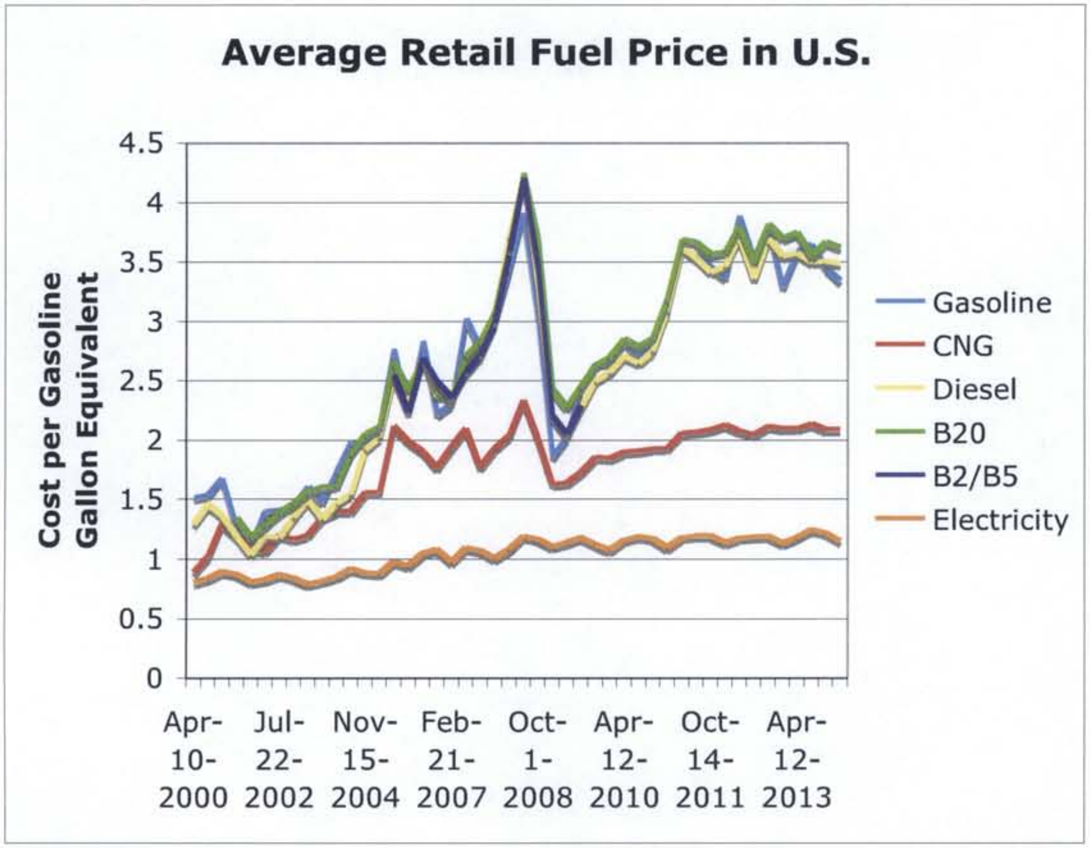

Figure 1: Average Retail Fuel Prices

Fuel volumes are measured in gasoline-gallon equivalents (GGEs), representing a quantity of fuel with the same amount of energy contained in a gallon of gasoline (Figure 1).

This chart shows average monthly retail fuel prices in the United States from 2000 to 2014. The price of petroleum fuels (gasoline and diesel fuel) is the primary driver of overall fuel prices. For as petroleum prices rise, so does demand for alternative fuels, thereby pushing their prices upward as well. However, natural gas and electricity prices have been buffered from this driver because transportation only constitutes a tiny portion of their markets. These two fuels are tied to each other, though, because over a quarter of all electricity is produced from natural gas.

Electric prices are reduced by a factor of 3.4 because electric motors are 3.4 times more efficient than internal combustion engines.

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Respectfully Yours,

Lawrence Lile, PE
Chair
Environment and Energy Commission