DRAFT - CNG Feasibility Study

Facility and Fleet Conversion

Kansas City Area Transportation Authority

May 2012

TranSystems
EXPERIENCE | Transportation

ACRONYMS

CEC	California Energy Commission
CH4	methane
CO	carbon monoxide
CO2	carbon dioxide
CNG	compressed natural gas
CWI	Cummins Westport, Inc.
DGE	diesel gallon equivalent
EIA	U.S. Energy Information Administration
g/bhp-hr	grams per brake horsepower hour
GHG	greenhouse gas
hp	horsepower
HRE	high release rate event
HVAC	heating, ventilation, and air conditioning
KCATA	Kansas City Area Transportation Authority
LRE	low release rate event
MBRC	miles between roadcall
mpDGE	miles per diesel gallon equivalent
mpg	miles per gallon
mph	miles per hour
NGV	natural gas vehicle
NGVTF	Natural Gas Vehicle Technology Forum
NOX	nitrogen oxide/oxides of nitrogen
NPV	net present value
NREL	National Renewable Energy Laboratory
ppm	parts per million
rpm	revolutions per minute

Executive Summary

The Kansas City Area Transportation Authority (KCATA) is the primary public transit provider in the Kansas City, Missouri metropolitan area. They currently operate from a central service facility at 1000 E. 18th Street in Kansas City, and currently operate in 3 counties in Missouri and 2 counties in Kansas. The KCATA's transit network features more than 70 Metro routes with an average of 52,000 daily boardings. The KCATA's fleet consists of 269 buses of various sizes, traveling an aggregate of 9.7 million miles yearly.

KCATA hired TranSystems to conduct a feasibility study to assist them in analyzing the impacts of converting to a Compressed Natural Gas (CNG) fleet. Fuel costs are currently the KCATA's single largest annual expense, compelling them to identify and implement means to reduce these costs. Because of the relatively stable cost for CNG and the projected increasing price differential with diesel fuel, conversion to a CNG vehicle fleet is an ideal way to reduce this expense. As part of this feasibility study, an evaluation of existing transit operations as well as the identification of the future needs of a CNG fleet conversion was conducted.

The main operational challenge for KCATA's CNG conversion is determining the location of a CNG fueling station on KCATA's property and applying building code requirements to existing structures. Four candidate locations are identified as having characteristics that could potentially house the CNG fueling facility. These options were developed after the consultant and staff surveyed potential sites within and surrounding KCATA's main facility.

This study determined that "Option D" best meets the site selection criteria used to evaluate the alternatives. This option is comprised of dedicated fuel and storage lanes on two of the southernmost bays of the site's existing storage building. A full-height, rated wall to separate the fueling lanes from adjacent storage would be required. Modifications to the HVAC and electrical systems would also be necessary in order to accommodate the CNG bus storage and fueling station.

The estimated cost to convert KCATA's storage and maintenance facilities to accommodate a CNG fleet is $5.2 million. This cost represents the Phase I of renovations. As KCATA's CNG Fleet grows, additional renovations will be required.

CHAPTER 1. Background and Purpose

Figure 1: KCATA Fleet Vehicle

Background

The Kansas City Area Transportation Authority (KCATA), the primary public transit provider in the bi-state Kansas City metropolitan area, currently operates diesel fueled buses from its central services facility. Faced with operating under challenging budgets while charged with maintaining a high level of service, the KCATA is continuously exploring methods to increase operational efficiencies. With fuel costs being the largest yearly budget expenditure, the KCATA focuses on trying to identify and implement means to reduce fuel costs. Prior actions have included replacing older, de-commissioned buses with a new generation of more fuel-efficient vehicles. The agency also aggressively seeks low-priced fuel through long-term fuel contracts as a hedge in the volatile fuel markets. Reducing unit fuel costs, even in small increments, can have a significant impact on agency operating costs considering the size of the KCATA fleet and miles traveled per year.

A fueling alternative that the KCATA staff is considering is compressed natural gas (CNG). The popularity of CNG is increasing and it is rapidly becoming the alternative fuel of choice for an increasing number of transit agencies across the country. With rising diesel fuel prices and the general volatility in petroleum-based markets worldwide, conversion of transit fleets from diesel to CNG has proven to be a prudent fiscal decision while helping to reduce our nation's dependence on foreign energy sources and reducing exhaust emissions. With respect to social benefits, it is generally accepted that implementation of CNG buses will reduce health risks through improved air quality and quieter running vehicles. The environmental impact of using CNG buses is significant. Studies have indicated a 20 percent reduction in lifecycle green house gas (GHG) emissions when compared to diesel buses.[1] Conversion to

[1] TCRP 146.

CNG is also consistent with national and local clean air initiatives to reduce greenhouse gas emissions.

Purpose

Recognizing the relatively stable cost for CNG, the projected increasing price differential with diesel fuel[2] and associated other benefits, the KCATA initiated this study to determine the technical and financial impacts of converting the current diesel-based bus fleet to CNG. The fundamental purpose of this feasibility study is to provide KCATA with information upon which to base decisions regarding the location and the technical scope of a CNG fueling facility conversion including the financial feasibility of CNG conversion. The primary benefit to the KCATA for this conversion is a reduction in fuel costs for the fleet while utilizing an increasingly popular domestic fuel source.

KCATA Operations

As the primary agency providing public transportation in the Kansas City metropolitan area, the KCATA currently operates in 3 counties in Missouri and 2 counties in Kansas. The KCATA's transit network features more than 70 Metro routes with an average of 52,000 daily boardings. The KCATA's fleet consists of 269 buses of various sizes, traveling an aggregate of 9.7 million miles yearly. All buses, regardless of route, type, or size are serviced, stored and dispatched from the central services facility at 1000 E. 18th Street in Kansas City, Missouri.

CNG Availability and Price Stability

Prior to 2008, CNG prices tracked consistently with crude oil prices. However, the relative price of CNG effectively "decoupled" and began to trade independently from crude oil prices beginning in mid-2008. The acknowledgement of vast national gas resources, new and effective means of gas extraction, and large available domestic supplies has helped in holding CNG prices stable in the face of volatile prices in the crude markets. Together with a growing national urgency to reduce dependence on foreign oil, the popularity of CNG as an alternative fuel source for a variety of public agencies has gained momentum. Based upon projections through 2025, the U.S. Energy Information Administration (EIA) proposes that natural gas will remain significantly less expensive than diesel fuel. EIA data also lists a projected cost escalation for diesel fuel of 1.8% and a projected escalation of 0.3% for CNG. This projected price stability and lower escalation of cost for

[2] www.eia.gov

CNG with respect to diesel fuel makes it a very attractive alternative fuel for the KCATA.

Facility Modifications

The decision to convert to CNG powered buses involves much more than just the purchase of new, specially equipped vehicles. The CNG conversion process is complicated and requires significant modifications to existing facilities as well as changes to long-established operational activities.

KCATA currently stores, maintains, fuels and services its transit fleet in indoor facilities. Because CNG has unique physical properties its use will impact fuel acquisition, storage and dispensing, mechanical requirements for maintenance and storage facilities, and maintenance procedures. In particular, CNG is lighter than air and, at concentrations between 5% and 15%, is flammable in air. Modifications will be required for buildings dedicated to indoor storage, maintenance, and fueling of CNG vehicles. In particular, modifications to facilities will be required to increase ventilation to code prescribed air change rates in addition to installation of rated electrical switches and connections in areas where CNG gas can accumulate.

CHAPTER 2. Overview of Compressed Natural Gas

Diesel Gallon Equivalents (DGE)
DGE = Amount of energy in one gallon of diesel fuel.
DGE = 128,450 Btu
DGE = 0.58 cubic feet of CNG @ 3,600 psi
DGE = 4.34 gallons of CNG @ 3,600 psi

General

Natural gas is a fossil fuel that typically consists of 90 percent methane (CH_4) with odorants added as a safety measure for detection. It is produced from gas wells drilled in a variety of locations and geologies across the country and is purified before distribution to consumers.

CNG is made by compressing natural gas to increase its energy density and reduce its storage volume requirements. CNG is typically compressed to less than 1% of the volume it occupies at standard atmospheric pressure. CNG's volumetric energy density is approximately 25% that of diesel fuel. As a comparative baseline, a Diesel Gallon Equivalent (DGE) is defined as the amount of energy in one gallon of diesel fuel. It requires approximately 125 cubic feet of natural gas at atmospheric pressure to equal one DGE. When compressed to 3,600 psi, this volume is approximately 0.58 cubic feet. While in this compressed state, CNG has approximately 25% of the energy of an equivalent volume of diesel fuel.

CNG has been recognized for decades as a viable alternative fuel for transit agency fleets. The number of transit and paratransit buses operating on CNG has grown rapidly over the past several decades. Approximately 30% of fixed-route transit buses operate on fuels other than diesel and 60% of those operated on CNG.[3] NGVAmerica identifies over 125 transit agencies that operated natural gas buses in 2009. This study highlights Los Angeles Metro's experience with CNG in the Appendix.

The use of CNG for fleets has certain advantages that should be weighed against some of the possible disadvantages.

Advantages

- Natural gas is domestically produced and widely available.
- Natural gas prices are projected to be relatively stable when compared with price projections for diesel fuel.

[3] www.ngvc.org

- CNG is the most widely used alternative fuel in transit bus fleets and transit agencies are comfortable with the technology.
- Per unit of energy, natural gas contains less carbon than any other fossil fuel, and thus produces lower carbon dioxide (CO_2) emissions.
- CNG buses meet 2007 EPA emission standards with little additional cost.
- Manufacturers are implementing CNG bus engine technologies that meet 2010 EPA NOx emission standards of 0.2 g/hp-hr.
- Reliability of CNG buses has increased and maintenance costs for CNG vehicles are on a par with diesel-based vehicles.

Disadvantages

- CNG requires fueling and maintenance facilities to meet code prescribed requirements for ventilation, electrical components, and safety.
- CNG facilities incur an additional electrical cost to power the compressors used to compress the natural gas to a usable form.
- CNG fueling facilities will require periodic maintenance for compressors and dryers to insure continuous operation.
- CNG buses require different maintenance operations than diesel buses.
- Natural gas transit vehicles use spark ignition engines, which have lower thermal efficiency than compression ignition (diesel).
- Natural gas transit vehicles have a significant fuel economy penalty of approximately 12% (measured in mpg) compared to diesel vehicles.

Safety

While natural gas is generally safe, there are safety precautions that must be taken into consideration. Flammability is generally considered the biggest concern. Natural gas is lighter than air and when released, it naturally moves upward. The possibility of gas temporarily concentrating anywhere from floor to ceiling inside of a building means that flammable conditions are possible in buildings housing CNG buses. To promote safety, early detection of any residual gas is imperative. This can be achieved by adding odorants to the gas so that one can detect it by smell or by utilizing natural gas detectors within a facility housing CNG vehicles. Other methods to improve safety include explosion-proof electrical devices and switches, limited heat sources, and ventilation methods that will quickly remove any pockets of natural gas.

The blue diamond symbol is typically used by emergency responders to identify CNG buses and facilities.

Training

It is imperative that CNG bus operators and maintenance personnel receive training on how to use and maintain CNG dispensing systems. Maintenance needs and maintenance schedules for CNG buses are different than for diesel buses. As part of the bus procurement process, most CNG bus manufactures offer extensive training to the transit agencies. Additionally, several organizations also offer supplementary training materials. Training information can also be obtained at www.cleanvehicle.org/technology.

Technology and Performance

Onboard Fuel Storage

The high-pressure storage cylinders used on transit vehicles are typically 6 to 12 inches in diameter and are located on the roof of most low-floor transit vehicles. On other transit vehicles, you might find the cylinders located underneath the bus or in the bus skirt-space above the engine. The cylinders generally are made of aluminum or carbon steel reinforced with composite materials to minimize weight. The CNG cylinders contain manual shut-off valves. The cylinders meet the NGV-2 standards of the American National Standards Institute. Common locations for methane detectors onboard transit vehicles are in the passenger area, the cylinder storage area and the engine compartment.

Refueling

A CNG refueling facility requires different equipment than what is used for diesel vehicles. In order to accommodate CNG vehicles it is typical that new fueling lanes be constructed on the transit site either retrofitting an existing fueling site or by designing new fuel lanes. If existing refueling takes place indoors then it is generally more economical to build a new fuel bay dedicated to CNG. This is due to the ventilation requirements necessary to accommodate CNG vehicles and fueling components.

It is not uncommon for transit operators to outsource the job of providing fuel and to contract fuel service providers to build and operate a refueling station.

Performance

Driving and maneuvering a CNG bus is very similar to operating a diesel bus. Some reports indicate that there might be a slight reduction in acceleration and hill climbing performance. CNG vehicles tend to be heavier than diesel vehicles which might explain the acceleration impacts. They also have reduced low-speed torque.

Maintenance, Reliability and Storage

The maintenance of CNG vehicles is slightly different than that of standard diesel buses. Some of the disparities include:

- Periodic spark plug replacements for spark-ignited engines. This is contrast to diesel engines, which are typically lower maintenance.
- Potentially greater frequency of brake and suspension replacements as a result of the CNG buses' heavier weight.
- Inspections of CNG fuel tanks.
- Maintenance of refueling equipment.

It is difficult to compare the reliability of CNG versus diesel buses because it varies significantly between all bus models regardless of fuel type. A 2006 study completed by the Washington Metropolitan Area Transit Authority reported an increase miles between road calls of its CNG vehicles but that data was slightly unreliable since the diesel buses were from a different manufacturer and were older than their CNG counterparts.[4]

Environmental Impacts and Emissions

Regulations of tailpipe emissions have become more stringent. Both diesel and CNG engine technologies have responded by enhancing the technology that addresses how exhaust gas is treated. In the past, diesel and CNG vehicle engines met similar standards for reducing Greenhouse Gas (GHG).

As engine technologies have advanced, natural gas vehicles have evolved and generally produce lower harmful emissions, including nitrogen oxides, particulate matter, and toxic and carcinogenic pollutants, compared to gasoline and diesel vehicles. And because natural gas contains less carbon than any other fossil fuel, CNG vehicles produce lower emissions of carbon dioxide, a principle greenhouse gas. By displacing conventional gasoline and diesel, CNG vehicles go further than any other alternative fuel in achieving the goal to reduce harmful air pollution and GHGs. It should also be noted that CNG vehicles are consistently ahead of gasoline or diesel vehicles in meeting or exceeding

[4] Chandler, K.E. Everts, and M. Melendez (2006). Washington Metropolitan Area Transit Authority: Compressed Natural Gas Transit Bus Evaluation.

government standards in emission performance. A 2007 study by the California Energy Commission found that CNG reduces GHG emissions by 23 percent in buses compared to their gasoline and diesel counterparts.[5]

The GHG emission that is of greatest concern with transit fleets is carbon dioxide. KCATA's fleet conversion to CNG will reduce GHG, reduce fuel cost, and reduce the cost of carbon dioxide emissions to society. In fact, carbon dioxide alone could be reduced by 17 percent.
When measuring and comparing GHG emissions of both diesel and CNG buses, it is best to look at the fuel lifecycle, which is referred to as well-to-wheels. Well-to-tank encompasses emissions from fuel exploration, development and production, delivery to fueling sites and the fueling process. Tank-to-wheels emissions include onboard sources such as tailpipe emissions.

The greatest portion of GHG lifecycle emissions from both CNG and diesel buses is from the tailpipe. GHG emissions vary depending on engine technology. A study performed in 2006 found that GHG tailpipe emissions were eight percent lower in CNG vehicles versus diesel vehicles. The engines on the CNG buses were 2006 lean-burn Cummins C-Gas Plus (ICG 280) and each CNG vehicle also had an oxidation catalyst.[6]

A later study comparing GHG emissions on CNG buses with stoichiometric engines, which are currently being manufactured and used today, versus lean-burn Cummins engines found that the stoichiometric engines reduced tailpipe GHG emissions 30 percent. The 30 percent reduction is only when comparing CNG engine variations to one another, but it indicates that the newer technology advances GHG emission reduction. In fact, Cummins Westport has reported that its 2010 natural gas ISL G engine provides a 17 percent reduction in tailpipe emissions over the cleanest comparable diesel engines.[7] This improvement is primarily from the stoichiometric engine's process for reducing unburned methane emissions. In general, emissions of GHG are approximately 10 to 20 percent lower with CNG buses than diesel buses.

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[5] http://www.afdc.energy.gov/afdc/vehicles/emissions_natural_gas.html
[6] TCRP 146.
[7] Westport News Release (February 6, 2006).

CHAPTER 3. Existing Conditions

General

KCATA has one central service facility on 18th Street in Kansas City that houses and maintains its transit fleet. The center is located in a valley, once drained by the O.K. Creek. As the city developed, the sewer was contained by a series of large sewers and the creek bed and surrounding valley was developed as home to a variety of residential and industrial neighborhoods as well as the primary rail artery through the city. The service center includes the main buildings in KCATA's central service facility that were constructed and went on line in 1977. A combination vehicular paint / body shop and administration building was constructed in 1992 at the facility. The service center includes three primary buildings (see Figure 2):

- Vehicular Maintenance Building (KCATA Building No. 1)
- Bus Storage Building (KCATA Building No. 2)
- Combination Administration – Paint/Body Shop Building

Supplementary structures include the sound control canopy structure on the northeast side of the bus storage building, a small fueling support building west of the vehicular maintenance building, and a fare retrieval building accessible by the bus entry on the west side of the center.

KCATA staff has long-established operational procedures involving concise bus movements that include fare collection, bus storage, bus maintenance, fueling and washing. It is the goal of the KCATA to maintain these movements to the greatest extent possible and to minimize the operational impacts from the introduction of CNG buses. Bus circulation is shown graphically on Figure 2 with bus entry/fare collection (orange arrow and servicing (blue arrow) movements distinguished from bus exiting (green arrow) movements. The bus routing has evolved to adjust to unique building functional layouts while allowing for one-way vehicular movements in the center of the site.

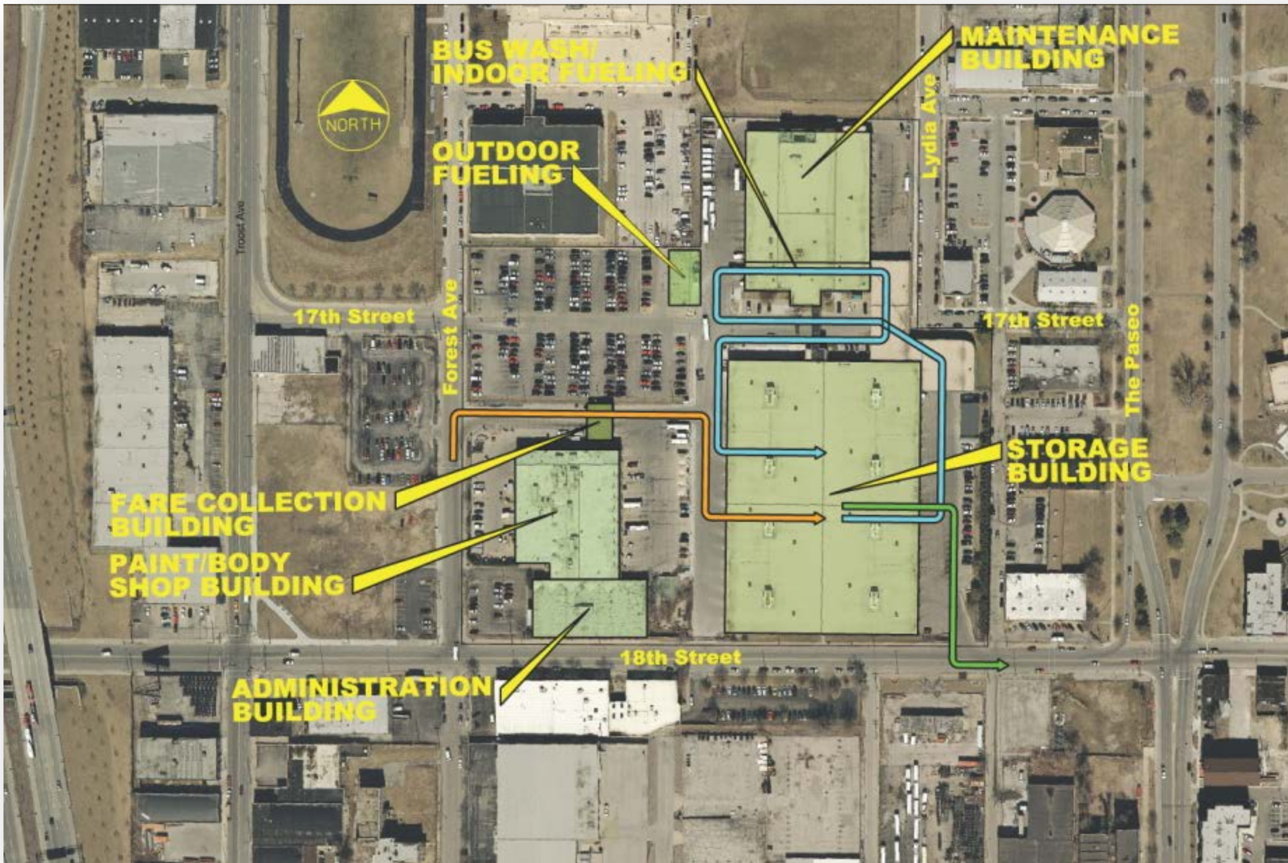

Figure 2: Existing Site Layout and Bus Maneuvering Paths

Bus Storage Building (KCATA Building No. 2)

Structural System - Anchoring the southeast quadrant of the service center property, the bus storage building is a 163,000 square-foot structure featuring multiple drive-thru bays to accommodate the KCATA's bus fleet for overnight storage (see Figure 3). The perimeter walls of the bus storage building are a series of 20-foot tall precast concrete, lightly sandblasted to achieve a uniform appearance with the other service center buildings. Bus access doors are located on the east and west faces of the building to accommodate a one-way movement of buses from west to east. The roof is comprised of a 2"-thick reinforced gypsum concrete deck supported by 24"-deep steel bar joists running east-west across the building. The building roof features a central, longitudinal ridge and slopes gently at 1/8" per foot to the east and west faces of the building. A series of roof drains are located along the east and west side of the roof. Supplementary steel framing is located at 8 locations on the roof to support the air-handling units serving the building for ventilation.

16"-deep steel wide-flange beams, bearing on 8"-deep wide-flange steel columns, support the bar joists. Columns are oriented on a grid pattern spaced at 25 feet north-south, and 41'-6" feet east-west (see Figure 4 for a view of a typical bus storage bay). Columns are founded on isolated reinforced concrete footings and perimeter walls bear on continuous concrete footings. Because of the building's extreme size, the structure is framed in quadrants separated by expansion joints. Expansion joint locations are discernible inside the building by double rows of columns. The floor of the building is a 6" thick concrete slab-on-grade.

Figure 3: View of East Side of Vehicle Storage Building

Structural Condition – In general, the bus storage building is in good condition. Some localized areas of interior column damage resulting from impacts from buses, was noted at different locations. Repairs, consisting of the installation of supplementary steel plates at the column bases, have been made on an as-needed basis at various times in the past. The roof structure appears in very good condition with no areas of excessive deflection or deterioration being visible. No areas of excessive slab subsidence or settlement of columns or perimeter walls were observed.

Figure 4: View Inside of Vehicle Storage Building (West Entrance facing East)

Mechanical / Electrical Systems – The mechanical ventilation system of the bus storage building is comprised of 8 roof-mounted air handling units that supply the exhaust and air supply for the building. These units, rated at 52,500 cfm each, have integral steam-powered heaters supplied by boilers located in the maintenance building.

The ventilation demands in the storage building are variable during a typical service day. Operations dictate that bus bay doors are open during large portions of the day to accommodate buses which have just completed routes or are engaged in servicing or storage procedures. During large portions of the day, different combinations of overhead bay doors are open on the east and west sides of the building. These open doors allow for the dominant amount of ventilation in the building required for code-prescribed air changes per hour.

Maintenance Building (KCATA Building No. 1)

Figure 5: View Inside of Vehicle Maintenance Building

Structural System – This two-story building serves as the primary vehicular maintenance building for the fleet and has a footprint of approximately 62,700 square feet. A 12,200 square-foot basement is located on the north side of the building and 6,100 square foot mezzanine is present in the central portion of the building. The main floor of the building is arranged with individual vehicular service bays along the east and west sides. The service bays are 60 feet long and require buses to enter or exit with a backing movement through individual roll-up doors. The 98 foot wide central spine of the building houses a variety of shops and parts storage areas. Administrative offices are located on the second floor above this central spine and are accessible through an elevator/stair lobby on the south side of the building. The building also features two drive-through service bays on the south end of the structure. These bays provide fueling and wash services for buses entering from the west and exiting to the east. Bus movements through the service lanes are noted on Figure 2. The maintenance building is physically connected to the bus storage building to the south by means of an enclosed pedestrian bridge. The bridge allows drivers and other personnel to pass between the structures while being protected from the weather. The bridge also serves as the means for routing steam pipes from boilers located in the maintenance building to heating units on the roof of the bus storage building to the south.

Figure 6: External View of Vehicle Maintenance Building (West Side)

The maintenance building is clad with precast concrete wall panels which are similar in appearance to surrounding buildings. The roof of the exterior maintenance bays is framed with precast double-tee beams spanning east to west and supported by concrete beams on the interior and the precast wall panels on the exterior. These beams slope down from the second story offices to the east and west faces of the building. The second floor offices, as well as the area of the first floor above the basement, and the mezzanine structure are framed with a reinforced concrete two-way flat slab system. Structural slabs in the central portion of the building are supported by concrete columns founded on concrete pile caps with various concrete pile configurations. The roof structure of the central office bank is comprised of a poured gypsum roof deck supported by 28" deep steel bar joists bearing on a series of 16" deep wide flange beams running longitudinally on the central grid. Joists bear on continuous integral corbels at the perimeter precast wall panels forming the walls of the office bank.

Impacts to Existing Buildings

The service center buildings that are primarily impacted by a fleet conversion to CNG fuel are the bus storage building and maintenance buildings. The ventilation and electrical systems of the existing maintenance and storage buildings are dated and do not meet current codes in many respects, the buildings have been inspected, are well maintained and are in good structural condition. Retrofitting the existing maintenance and storage buildings for CNG buses is more economical than constructing new facilities and will be less disruptive to established operational procedures.

CHAPTER 4. Evaluation of CNG Fueling Site Location

The CNG fueling facility requires an optimal location to accommodate the complex requirements of a CNG fueling system. An ideal location must enable KCATA to efficiently service its fleet, today and in the future with little interruption to their daily operations. Through a series of meetings with staff, CNG experts and Missouri Gas Energy, several sites were identified as possible locations for the CNG fueling facility. A CNG fueling facility for the KCATA would require two CNG fueling dispensers, storage tanks and up to three natural gas compressors. In order to accommodate an operation of this magnitude several criteria were developed that provide an evaluation mechanism suitable in identifying the "preferred" option among the list of possible alternatives.

In this phase of the feasibility study, the consultant has conducted the analysis based on the following general basic tenets:

- The preferred option shall not have detrimental impacts on any KCATA function.
- The preferred option shall be practical and defensible under scrutiny.
- The preferred option shall serve as a basis for obtaining funding for implementation.

The following criteria were used for evaluation of the prospective sites:

Proximity to CNG Supply
It is ideal for the preferred site be located nearest to the natural gas supply at KCATA's site. The greater the distance between the supply and the fueling/storage location, the more pressure is required to condense the fuel to 3600 psi. This would, in turn, require more energy and create inefficiency in condensing the fuel to the necessary pressure required to operate a CNG bus.

Impact on Traffic Flow, Operations, Parking
The preferred site will allow for safe operating conditions for KCATA vehicles and KCATA staff. This criterion focuses on safe access throughout the KCATA facility for both vehicles and pedestrians.

Site Development Requirements

Numerous factors affect the development cost of the site, including existence of structures, proximity to needed utilities, and site access. The preferred option should limit disruption of current KCATA operations.

Expandability

The preferred site will be readily expandable as KCATA's CNG fleet grows. The site should have enough space to accommodate additional fueling tanks and also be able to potentially accommodate more fuel dispensers if required. Furthermore, the expandability of the storage capabilities of the facility is also a critical element as the number of CNG fleet vehicles grows.

Improvements

The preferred site will require the fewest improvements in order to accommodate a CNG fueling site. For example, one of the requirements of the fueling site will be to provide protection from the elements. A site with natural shelter elements and protective qualities could be viewed as a more favorable location.

Options

Four candidate options as shown on Figure 7 were identified as having characteristics that could potentially house the CNG fueling facility on the KCATA property. These options were developed after the consultant and staff surveyed potential sites within and surrounding KCATA's main facility. A detailed discussion of each option as well as each option's advantages and disadvantages follows.

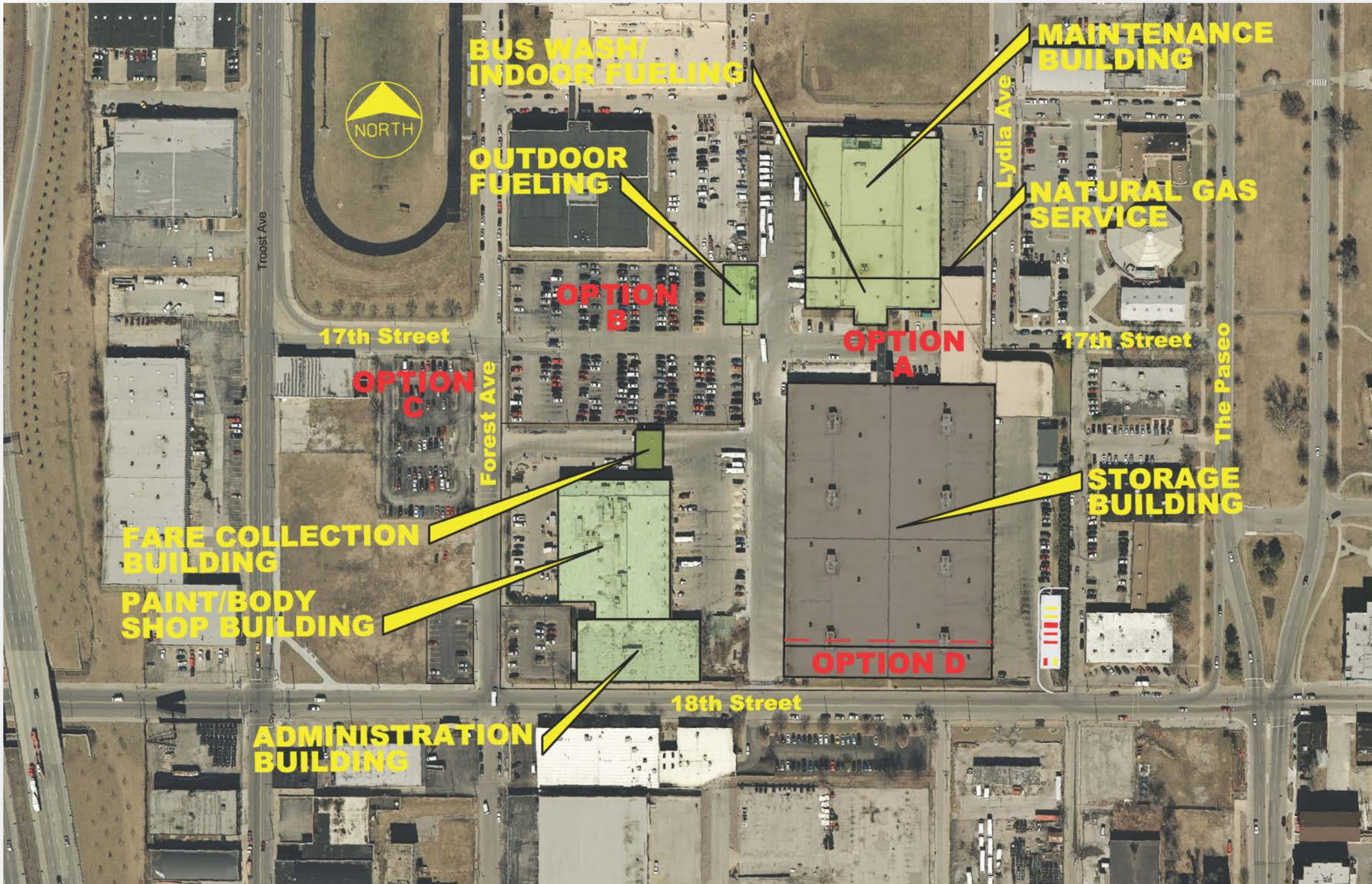

Figure 7: Location of Options

Option A: Option A is situated between buildings 1 and 2 as illustrated on Figure 7. This option would consist of a single canopy protecting two CNG fuel dispensers. Bypass lanes on the north and south sides of the fueling facility would allow bus through movements for vehicles not utilizing the CNG station. In order to accommodate the fueling facility, several modifications would be required at this location.

Advantages:

1. This location has few conflicts with the existing path that transit vehicles travel in order to wash, refuel and park.
2. This option displaces the least number of parking spaces for KCATA staff.
3. Because the site is surrounded by existing structures, fewer wind and element barriers would be required at this location.
4. This location is close to the natural gas outlet on site.

Disadvantages:

1. Approximately 7 to 14 parking spaces would be displaced by this option.
2. The site is framed by existing KCATA structures on the north and south and is also bordered by a noise-dampening canopy to the east. These existing barriers have the potential to limit the future growth of the fueling station as more CNG vehicles are added to the transit fleet requiring greater fueling capacity.
3. The location of the support columns on the noise-dampening canopy might be problematic and require structural modifications in order to accommodate the fueling facility.
4. It would be challenging to fit all of the fueling components at this location and maintain bypass lanes for bus travel.
5. This location is situated directly under the pedestrian bridge that connects Buildings 1 and 2.
6. There are large sewer mains located directly under this site, which presents a future maintenance problem.

Option B: Option B is situated at the northernmost half of the existing staff parking lot just south of Manual Career Technical School as illustrated on Figure 7. As with the previous option, this option would consist of a single canopy protecting two CNG fuel dispensers.

Advantages:

1. Because the site is bordered by an existing structure to the north, fewer wind and element barriers would be required at this location.
2. There are few physical constraints that would prohibit a fueling site at this location.
3. This location has space to be readily expandable as the CNG fleet grows.

Disadvantages:

1. This location could potentially conflict with the existing path that transit vehicles travel in order to wash, refuel and park.
2. Approximately 108 parking spaces would be displaced with this option requiring the relocation of those spaces to the parcel across Forest Avenue to the west of KCATA's main facility. This would, in turn, require staff to park farther away from where they currently park.
3. This site is located farther than Option A from the natural gas outlet onsite.

Option C: Option C is located off-site on an approximately one acre parcel of land located to the west of KCATA's main facility just across Forest Avenue and is shown on Figure 7. This option would consist of a canopy protecting two CNG fuel dispensers..

Advantages:

1. This site has an ample amount of space and would accommodate efficient maneuvering of the buses during fueling.
2. The acreage of this site would allow for expansion as the CNG fleet grows.
3. This option displaces the least number of parking spaces for KCATA staff, but would still displace visitor and operator parking.

Disadvantages:

1. Due to its location off site, this location could potentially conflict with the existing path that transit vehicles travel in order to wash, refuel and park.
2. This site is located outside the existing, secure fence line. This would require that secure fencing be expanded to this location.
3. Buses could potentially be required to utilize 18th Street in order to gain access to the fueling site.
4. Utilities would need to be extended to this location in order to accommodate the fueling facility.
5. This site is located far from the KCATA's existing natural gas outlet.
6. Because there are few existing structures at this location, more protective elements would be required to shield staff from the weather conditions

Option D: This option, as illustrated on Figure 7, is comprised of dedicated fuel and storage lanes on two of the southernmost bays of the existing storage building (Building 2). This option would consist of modification of existing bays to provide two CNG fuel dispensers. A full-height, rated wall to separate the fueling lanes from adjacent storage would be required. Modifications to the HVAC and electrical systems would also be necessary in order to accommodate the CNG bus storage and fueling station.

Advantages:

1. This location would accommodate the fueling, wash and maintenance maneuvers as they are currently performed on KCATA's site with few adjustments.
2. This site would provide an interior fueling facility, which provides protection from all elements.
3. As illustrated on Figure 7, this site would locate the compression and fuel storage to an underutilized corner on KCATA's site.
4. As the CNG fleet grows, the building can be efficiently modified in incremental stages which will limit disruption to existing KCATA operations.
5. This option will not displace parking.

Disadvantages:

1. Extensive modifications to the existing storage building would be required in order to meet current code requirements as they pertain to ventilation, electrical, switches and safety.
2. This site is located far from the KCATA's natural gas source and would require installation of a natural gas outlet near the fueling components.
3. This option would eliminate some bus storage.

Preferred Alternative

Based on the criteria previously outlined and through a detailed examination of the advantages and disadvantages of each option, Option D is the recommended site for the location of the CNG Fueling Facility.

CHAPTER 5. Required Facility Modifications

Overview

Several facility modifications are required in order to accommodate the various components of the CNG conversion. The most significant changes to operational procedures will be in the areas of storage and maintenance activities.

Storage Facility Modifications

The bus storage building is used to store KCATA's bus fleet overnight and when individual units are out of service during the day. Buses are generally stored in the building for several hours.

The primary concern with storage buildings containing CNG vehicles is the potential release of natural gas from the vehicles. At normal temperature and atmospheric pressure, natural gas has a density of 55% of air and therefore tends to rise if released from a vehicle. This release of gas can be classified as two particular release events. A High Release Rate Event (HRE) is usually the result of a serious failure involving fuel lines, the storage cylinders, or pressure relief devices. A HRE results in a large volume of gas being released and creates a significant hazard inside a storage building. Gas concentrations from a HRE could remain at the flammable limit and could be ignited until the gas dissipates through enhanced ventilation. A Low Release Rate Event (LRE) is generally characterized by small volumes of gas being released from loose fittings, connections or gaskets in the fuel system. Since a LRE involves a small volume of gas that generally dissipates quickly, it is not regarded as a significant hazard like an HRE.

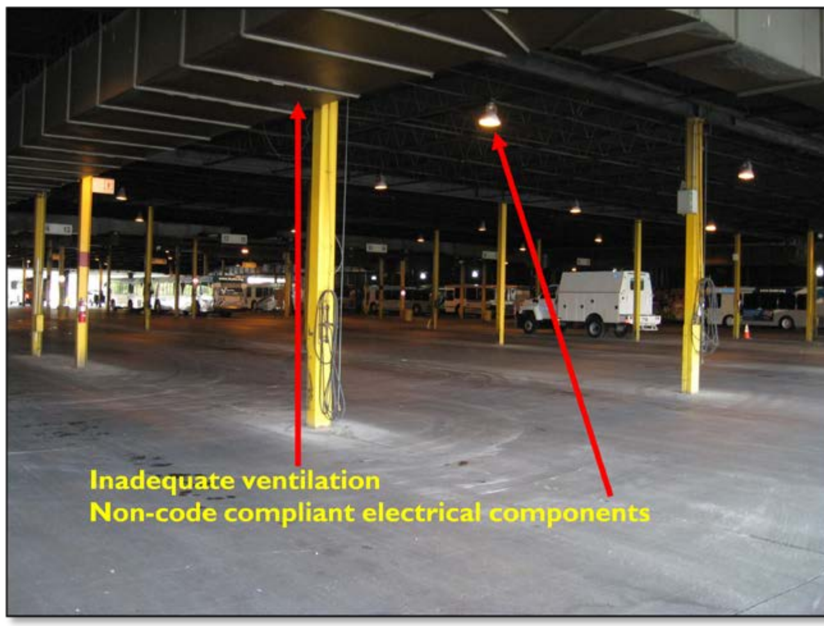

Figure 8: Existing Bus Storage Building

Regardless of the type of leak event, there is always the possibility of a flammable mixture of natural gas and air collecting in certain areas of the structure. Current codes require an enhanced ventilation rate of 6 air changes per hour in a storage building to mitigate the collection of gases. Additionally, the ventilation design should eliminate dead air zones which can be caused by certain structural framing schemes. While this is not a concern in the bus storage building because of the open web joist framing system, it is a concern in the bus maintenance building where a precast rib roof system could lead to the accumulation of gases. As an additional safety component, gas sensors will be located at various locations in all the buildings. These sensors will be tied into an audible alarm system that will work integrally with the ventilation (exhaust fans and make up air) to insure proper air flow rates to reduce the gas concentration in the building.

From an electrical perspective, ignition sources are of primary concern in the bus storage building. Equipment with surface temperatures above 800 degrees F will be identified and eliminated as will spark generating equipment or switches. Exhaust fans will be rated to work in a gas-rich environment.

CNG Fueling System

For use in buses, natural gas is compressed to 3,000 - 3,600 psi to increase fuel density and to increase the amount of fuel that can be stored. Natural gas for the KCATA CNG fueling facility will be supplied by local carriers, and will arrive at the site at pressures that will require substantial compression before dispensing to a bus. It is imperative that the new fueling facility include two compressors in the initial build-out to insure redundancy should one of the compressors not function. It is anticipated that two additional compressors will be added in the future to accommodate the full bus fleet per the bus replacement schedule. The CNG compressors will require an upgrade in electrical capacity at the facility. The fueling system will also include high pressure storage tanks and a dryer to remove moisture from the compressed gas located on the southeast corner of KCATA's site.

The fueling facility will utilize "fast fill" operations for fueling buses to meet daily fueling needs for the KCATA fleet. Fast filling most closely resembles diesel fueling with respect to time as well as maintaining the sequential queuing of buses currently utilized. As a first phase of CNG conversion, an enclosed fueling facility will be constructed in the two southernmost bays of the existing bus storage building. As the CNG fleet grows, additional storage bays would be converted to accommodate CNG vehicles.

The Code requirements regarding indoor fueling are very restrictive for ventilation and deflagration. In general, the storage building will require deflagration venting which can be light weight panels or similar materials that will blow out in the event of an interior explosion, providing means for internal pressures to be relieved. National Fire Protection Association (NFPA) codes require deflagration ventilation on roughly 40 percent of the surface areas of enclosed fueling bays. This would require the removal and reconfiguration of the walls and roof framing on the southern end of the storage building to accommodate the proper ventilation. A more practical approach, and one that is recommended, would be to convert the south end of the storage building to fueling lanes with the south wall being predominantly open. This will allow the fuel lanes to be interpreted as the equivalent of an open air facility. A detailed list of the NFPA code requirements for CNG fueling facilities are attached in the Appendix.

CHAPTER 6. Estimate of Probable Cost

Using current unit costs for the construction and facility modifications required for Option D, an opinion of probable cost shown in Figure 8 was prepared. The opinion of probable cost is based on a particular construction scenario required for the preferred alternative. As the design is more fully developed, this cost estimate would be refined. A detailed cost estimate is provided in the Appendix.

Figure 8

Estimate of Probable Cost (2012 dollars)

Category	**Cost (thousands)**
Storage Building Renovation	$2,707
Maintenance Building Renovation	$1,400
Site Demolition/Clearing	$40
Site Development/Preparation	$74
Subtotal:	$4,221
Contingency and Escalation (24%)	$1,013
Total:	$5,234

CHAPTER 7. Benefit Cost Analysis

In addition to the cost estimates determined in this study, this further economic analysis quantitatively examines the costs and benefits of replacing the KCATA's diesel-fueled bus fleet with CNG-fueled vehicles. This analysis is based on fleet data obtained from the KCATA through questionnaires, interviews and annual fleet and budget reports. The principal structure used for this analysis is the National Renewable Energy Laboratory's CNG Vehicle and Infrastructure Cash Flow Evaluation (VICE) model with certain modifications that were appropriate for the unique parameters of the KCATA operations. Using this customized analytical model as a guide, a broad range of monetary costs and benefits associated with fleet conversion to CNG vehicles was analyzed. This benefit-cost analysis goes beyond solely determining feasibility of the technical facility conversion to include fleet conversion costs, societal and environmental elements.

This cost-benefit model analyzes the Net Present Value (NPV) of the purchase and operation of the CNG fueled buses and includes costs for facility conversion to accommodate these vehicles. The model determines the NPV of a string of costs and benefits over a period beginning in 2013. The NPV of the costs and benefits are compared on a yearly basis. The theoretical "pay back" period for the investment is defined as the point where NPV of benefits exceeds NPV of costs. As an additional point of comparison, No-Build analysis which assumes a continuation of diesel-based bus service, was performed and is included in the Appendix. This baseline option, shows the financial impact of a No-Build scenario where the KCATA would maintain the current fleet composition.

Approach

This benefit cost analysis was performed using the following assumptions and anticipated operating parameters as defined by the KCATA:

- the KCATA will retire its diesel fueled bus fleet on a prescribed schedule consistent with FTA useful life and replacement requirements (generally, after 12 years of use);
- the CNG buses to be acquired as part of the project will be included in the overall analysis;

- based on the current replacement schedule, the entire bus fleet will be replaced in approximately 14 years with the initial block of CNG buses being purchased in 2014;
- as buses are retired, they will be replaced with CNG fueled vehicles;
- the fleet size will remain constant at 269 vehicles into the future;
- the current bus fleet averages 35,967 miles per vehicle per year, based on 269 active vehicles;
- based on historical diesel fuel purchases and average miles per vehicle per year per KCATA published data, the average fuel consumption per bus is 4 miles per gallon of diesel for the analysis;
- the KCATA plans to maintain existing storage and maintenance facilities at its central service facilitiy and make modifications to these facilities incrementally to accommodate the fleet changeover; and
- the KCATA plans to construct a new CNG fueling facility at its central service facility base to serve the bus fleet.

The model also includes other parameters that affect the analysis. The discount rate used for the NPV analysis is 3%.

Explanation of Costs and Benefits

Conversion from diesel fueled buses to CNG fueled vehicles involves several cost components. In addition to the purchase of new CNG buses, there are associated costs and certain assumptions that were defined and incorporated into the analysis.

Vehicle Costs - For the purpose of this analysis, only the incremental increase in cost of a CNG-based bus over a diesel-based bus is included. Buses will be replaced on a prescribed schedule so only the additional expense of CNG vehicles is relevant to the analysis. This incremental cost difference varies depending on bus size and options included for the particular bus model and may range from $30,000 to more than $50,000. Conservatively, this analysis assumes a price difference of $50,000 per bus and agrees with NREL data.[8] No inflation factor has been applied to this difference as it is assumed that the price difference will remain constant into the future.

[8] NREL Technical Report: NREL/TP-7AZ-47919, June 2010, "Business Case for Compressed Natural Gas in Municipal Fleets."

Fuel Costs and Fuel Economy- Savings from the significant cost difference between diesel and CNG fuels is the primary benefit incorporated into the cost-benefit analysis. CNG prices are lower than diesel and are projected to remain relatively stable. The KCATA's single largest annual expense is fuel, and CNG offers an immediate means to lower fuel costs. This savings is evident although CNG vehicles are slightly less efficient with respect to fuel economy. This difference in efficiency is more pronounced in fleets with lower average speeds. With an average bus speed of 11 miles per hour (mph), KCATA's diesel fleet has an average fuel economy of 4.0 miles per gallon (mpg). This analysis assumes an 18% efficiency reduction for CNG buses. This efficiency estimate is consistent with the range of observations of the NREL Subcontract Report NREL/SR-7A2-48814[9] and TCRP Report 132.

Based on the Annual Energy Outlook report (2011) from the U.S. Energy Information Administration (EIA)[10], natural gas costs are projected to remain significantly below diesel fuel costs through 2035. This analysis assumes three scenarios: a 1.8% growth rate in diesel cost and a 0.3% growth rate for CNG as a conservative estimate, a mid-range or baseline estimate of 4.1% and 2.4% respectively and a high end estimate of 6.4% and 4.5% respectively. Costs per gallon of diesel fuel, $3.00 for the last quarter of 2011, is based on current long-term contracts that the KCATA has with suppliers. Current costs per diesel equivalent gallon (DGE) of CNG fuel for the analysis is set at $1.51 per gallon and is based CNG costs currently under contract for the City of Kansas City, Missouri with modifications. Modifications include a $0.14 per DGE energy cost associated with additional electricity costs for gas compression at the proposed CNG fueling facility. Although the federal government currently offers the Alternative Fuel Excise Tax Credit of $0.50 per DGE, this incentive expired at the end of 2011 and, conservatively, was not included in this analysis.

As stated in the Problem Approach, the number of bus miles driven and the associated fuel consumption was taken from data produced by the KCATA.

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[9] NREL Technical Report: NREL/SR-7A2-48814, September 2010, "Compressed Natural Gas (CNG) Transit Bus Experience Survey."
[10] Annual Energy Outlook, 2011: http://www.eia.gov/forecasts/aeo/pdf/0383(2011).pdf

Facility Upgrades – The conversion to a CNG bus fleet requires a comprehensive approach to facility upgrades. The primary upgrades required for transit vehicle storage, wash bay, and maintenance facilities center upon enhanced ventilation requirements (6 air changes per hour required) and more stringent requirements for explosion proof electrical switches, equipment and building components such as deflagration ventilation. A team of mechanical, electrical, and plumbing engineers has inspected the KCATA transit vehicle storage and maintenance buildings and estimated costs for replacing the ventilation, heating and components of the electrical systems not meeting current code requirements for facilities accommodating CNG buses. The estimated costs for the facility upgrades are included in the analysis and take place primarily in year 1 with supplemental facility upgrades to complete the implementation of the CNG fleet in outlying years.

The CNG fueling facility will be constructed with two compressors initially and will be able to initially support up to 100 buses for fueling. There are also two major costs for additional compressors in the outlying years for servicing the entire fleet of 269 buses. An estimated allowance for electrical upgrades has been included to meet the enhanced electrical power requirements for the compressors as well as annual maintenance fees for the facility for the duration of the project. Conservatively, no Alternative Fuel Infrastructure Tax Credit, which can total $50,000, is included in this analysis.

Salvage Value Costs - Salvage values for facility improvements and CNG buses purchased include the following:

- salvage value of the incremental costs of the CNG buses that will purchased in the project period of 14 years;
- salvage value for buses is based on an anticipated useful life of 14 years (duration of project);
- salvage value of the facility upgrades for the maintenance/wash, bus storage, and construction of the CNG fueling facilities with major compressor additions in outlying years;
- salvage value for facility upgrades and construction is based on a useful life of 20 years;
- salvage values for buses or facility upgrades is based on a linear reduction of value as a function of asset age with respect to anticipated useful life.

Project Benefit / Cost Analysis Table – The Benefit/Cost Analysis table (Figure 9) below summarizes the anticipated Benefit/Cost ratios utilizing three different fuel escalation rates. The baseline, or mid-range estimates that diesel fuel prices will escalate at a rate of 4.1% while CNG rates will increase at 2.4% give the total project a payback period of 11 years. Separate analysis was conducted utilizing a low price escalation rate and a high price escalation rate to illustrate the potential payback periods associated with the varying scenarios. The analysis indicates a Benefit / Cost ratio of 1.61 in the baseline scenario for the project considering all applicable costs and benefits. The comprehensive analysis is located in the Appendix.

Figure 9
Benefit-Cost Analysis Summary

Description	CNG	Diesel
Low		
Escalation Rates:	0.3%	1.8%
Payback Period:	12 years	
B-C Ratio:	1.26	
Baseline		
Escalation Rates:	2.4%	4.1%
Payback Period:	11 years	
B-C Ratio:	1.61	
High		
Escalation Rates:	4.5%	6.4%
Payback Period:	10 years	
B-C Ratio:	1.95	

CHAPTER 8. Summary of Recommendations

The primary purpose of this feasibility study is to provide KCATA with information upon which to base decisions regarding the location and the scope of a CNG fueling facility conversion including the financial feasibility of CNG conversion. This section summarizes the conclusions and recommendations from the feasibility study.

Option D is the preferred site for the location of the CNG Fueling and Storage area:

- This location would accommodate the fueling, wash and maintenance maneuvers as they are currently performed on KCATA's site with few adjustments.
- This site would provide an interior fueling facility, which provides protection from all elements.
- This site would locate the compression and fuel storage to an underutilized corner on KCATA's site.
- As the CNG fleet grows, the building can be efficiently modified in incremental stages which will limit disruption to existing KCATA operations.
- This option will not displace staff parking.

Several facility modifications are required in order to accommodate the various components of the CNG conversion. The most significant changes to operational procedures will be in the areas of storage and maintenance activities.

In addition to electrical and ventilation upgrades in the storage and maintenance building, an enclosed fueling facility would be constructed in the two southernmost bays of the existing bus storage building. Code requirements regarding indoor fueling are very restrictive for ventilation and deflagration. In general, the storage building will require deflagration venting which can be light weight panels or similar materials that will blow out in the event of an interior explosion, providing means for internal pressures to be relieved.

Using current unit costs for the construction and facility modifications required for Option D, the estimated cost of the first phase of facility conversion is $5.2 million. If KCATA chooses CNG conversion it is expected that the overall “pay back” period could be approximately 11 years.

Appendix

Transit Agency Case Study

LA County Metropolitan Transportation Authority – Interview on April 24, 2012 with John Drayton, Manager of Vehicle Technology

Motivation behind conversion to CNG Fleet: Environmental and external regulatory factors motivated Metro to move toward clean fuel vehicles.

How CNG Operations are funded: Federal funding contributes up to $2 Billion annually. State funding provides between $0.5 and $1 Billion annually. There are three, local half-cent sales taxes that provides up to a $1.5 Billion annually. State funding is the biggest variable year to year.

How is fuel and fueling facility contracted: Metro contracts all of its CNG fuel and its CNG fueling system maintenance. Their contractor builds, operates, maintains and provides fuel for their entire fueling system. The service provider is under contract to respond to all emergency fueling issues and fix any problems with Metro's fueling system as they arise. They currently use Clean Energy as their contractor, and they are very happy with them.

Mr. Drayton emphasized the importance of utilizing a contractor for the fueling system. Early on, Metro self-maintained their system and the maintenance personnel would receive monthly if not weekly emergency calls to maintain the CNG fuel system. The contractor is now in charge of those calls and it has greatly eased the operational burdens of their maintenance department. Mr. Drayton stated that these systems are so unique that having a company like Clean Energy maintain the systems is imperative.

Overall, Mr. Drayton stated that determining whether or not switching to CNG would be successful is based on each individual transit agency. Each agency has a plan and CNG must fit in that plan in order for it to be a success. He experiences approximately a 60 percent fuel savings, but emphasizes that overall maintenance of each vehicle is approximately 15-20 percent greater. As technology on CNG vehicles gets better through demand, the maintenance cost will only be reduced. He estimates that Metro has reduced the cost of overall vehicle operations 20 percent by utilizing CNG technology.

Code Review

Condition: Outdoor Compression & Storage of CNG / Indoor Dispensing

References: NFPA 52 – 2010

Applicability: Code applicability is discussed in italicized comments following individual code references below.

8.4 Outdoor Siting

8.4.2.1 Containers. CNG storage containers stored with CNG not connected for use whall be located outdoors. (*Proposed location of CNG storage and compression facility will be located outdoors).*

8.4.2.2 Equipment Shelter or Enclosure. A facility in which CNG compression, storage, and dispensing equipment are sheltered by an enclosure that is constructed of noncombustible or limited-combustible materials and that has at least one side predominantly open and a roof designed for ventilation and dispersal of escaped gas shall be considered to be located outdoors. (*Proposed location of CNG storage and compression facility will have a steel-framed canopy to protect equipment from the elements. Proposed dispensing area inside the bus storage building is constructed of non-combustible materials. Dispensing lanes will have louvers/deflagration panels meeting NFPA requirements.)*

8.4.2.4 through 2.9 System Siting. Pertaining to compression, storage and dispensing system:

Facility shall not be less than 10 feet from the nearest public street, sidewalk, and at least 50 feet from nearest rail or any railroad main track. *(Proposed location of compression, storage, and dispensing facility meets this requirement.)*

A clear space of at least 3 feet from shall be provided for access to all valves and fittings of multiple groups of containers. *(Requirement will be followed by CNG facility provider.)*

Readily ignitable material shall not be permitted within 10 feet of any stationary container. *(This is an operational requirement that will be followed by the KCATA.)*

The minimum separation between containers and aboveground tanks containing flammable or combustible liquids shall be 20 feet. *(This is an operational requirement that will be followed by the KCATA.)*

Areas for compression, storage, and dispensing shall be classified in accordance with Table 8.4.2.9 for installations of electrical equipment. *(Design requirements per NEC Article 505, pertaining to electrical design requirements, will be met by CNG facility provider and be incorporated into the design of the interior dispensing area.)*

8.4.3.1 Indoor Siting – General. Compression, dispensing equipment, and storage containers connected for use shall be permitted to be located inside of buildings reserved exclusively for these purposes or in rooms within or attached to buildings used for other purposes in accordance with this section. *(The location of the dispensing lanes in the existing storage building is in accordance with this provision.)*

8.4.3.2 Limits of Storage in Buildings. Storage shall be limited to not more than 10,000 scf (standard cubic feet) of natural gas in each building or room. Exception: CNG stored in vehicle mounted fuel supply containers. *(A section of the existing bus storage building will be converted to storage for CNG buses and meets this code provision.)*

8.4.3.3 Deflagration Venting. Deflagration (explosion) venting shall be provided in exterior walls or roof only. Vents shall be permitted to consist of any one or any combination of the following:

- Walls of light material;
- Lightly fastened hatch covers;
- Lightly fastened, outward opening doors in exterior walls;
- Lightly fastened walls or roofs

  Note: For information on venting of explosions see NFPA 68, *Guide for Venting of Deflagrations*.

  Note: Where applicable, snow loads shall be considered.

  (This is an operational requirement that will be followed by the KCATA.)

8.4.3.4 Rooms Within Buildings.

- Rooms within or attached to other buildings shall be constructed of noncombustible or limited-combustible materials.
- Interior walls or partitions:
  - Shall be continuous from floor to ceiling:
  - Shall be securely anchored; and
  - Shall have fire resistance rating of at least 2 hours.
  - At least one wall shall be an exterior wall.

  Exception: Window glazing shall be permitted to be plastic.
  - Explosion venting shall be provided in accordance with 4-4.3.3;
  - Access to the room shall be from outside the primary structure.

  Exception: If such access is not possible, access from within the primary structure shall be permitted where wuch access is made through a barrier space having two vapor-ceiling, self-closing fire doors having the appropriate rating for the location where installed.

  (This is an operational requirement that will be followed by the KCATA.)

8.4.3.5 Ventilation Inlets and Outlets

- Indoor locations shall be ventilated using air supply units and exhaust outlets arranged to provide uniform air movement to the extent practical.
- Inlets shall be uniformly arranged on exterior walls near floor level.
- Outlets shall be located at the high point of the room in exterior walls or the roof.
- Ventilation shall be by a continuous mechanical ventilation system or by a mechanical ventilation system activated by a continuously monitoring natural gas detection system where a gas concentration of not more than one-fifth of the lower flammable limit is present. In either case, the system shall shut down the fueling system in the event of failure of the ventilation system.
- The ventilation rate shall be at least 1 ft^3/min. per 12 ft^3 (1 m^3/min. per 12 m3) of room volume.
  (Note: this corresponds to 5 changes per hour)
- A ventilation system for a room within or attached to another building shall be separate from any ventilation system for the other building.
  (This is an operational requirement that will be followed by the KCATA.)

8.4.3.6 Where installed, a gas detection system shall be equipped to sound a latched alarm and visually indicate when the maximum of one-fifth of the lower flammable limit is reached.

8.4.3.7 Reactivation of the fueling system shall be by manual restart and shall be conducted by trained personnel.

8.4.3.8 Buildings and rooms used for compression, storage, and dispensing shall be classified in accordance with Table 8.4.2.9 for installations of electrical equipment.

8.4.3.9 Non-electrical Ignition Sources shall not be permitted.

8.4.3.10 Pressure Relief Devices. Pressure relief devices on storage systems shall have pressure relief device channels [See 4.5.1(3)] to convey escaping gas to the outdoors and then upward to a safe area to prevent impinging on buildings, other equipment, or areas open to the public (e.g., sidewalks).

8.4.3.11 Warning Signs. Access doors shall have warning with the signs with the words "WARNING – NO SMOKING – FLAMMABLE GAS." Such wording shall be plainly legible, bright red letters on a white background, with letters not less than 1 in. (25 mm) high.

8.4.3.12 Indoor Fast-Fill Fueling, Outdoor Storage, and Compression. Fast-fill fueling indoors is permitted where storage and compression equipment is located outdoors complying with 8.4.2.1 through 8.4.2.7 and 8.2.4.9.

8.4.12.1 Where attended fast-fill fueling is performed indoors:

- An emergency manual shutdown devise shall be installed as required by 8.11.5
- A gas detection system equipped to sound an alarm and visually indicate when a maximum of one-fifth of the lower flammable limit is reached shall be installed.

8.4.12.2 The actuation of the gas detection system shall shut down the compressor and stop the flow of gas into the structure.

DRAFT KCATA CNG Conversion Cost Estimate (Phase I)

Project Budget Analysis **May 10, 2012**

(Areas for facility functions based on programming analysis.)

CATEGORY OF COST	QUANTITY AREA/NO.	UNIT	COST	LINE ITEM COST	COMMENTS/REMARKS
A. Construction Costs					
1. Vehicle Storage Building					
1) Ventilation, Mionitoring and Electrical Upgrade (Phase I)	68,000	SF	$ 30	$ 2,040,000	
2) Supplemtnary Bracing of South Wall	11,880	LB	$ 3	$ 29,700	
a. Foundation Modifications	8	EA	$ 2,500	$ 20,000	
b. Wall Framing	50,158	LB	$ 2	$ 75,237	
c. Louvered Wall System	5,950	SF	$ 40	$ 238,000	
4) Rated Wall (between Fueling and CNG Storage and between CNG Sroage and Disel Storage)	11,900	SF	$ 10	$ 119,000	
				$ -	
a. Sawcut for Footings	680	LF	$ 1	$ 680	
b. Concrete Removal	2	EA	$ 1,300	$ 2,600	
c. Soil Removal	300	CY	$ 8	$ 2,400	
d. New Footings	120	CY	$ 300	$ 36,000	
5) Reconfiguring External Electrical Service (South Face of Building)	1	EA	$ 10,000	$ 10,000	
6) Gas Main Installation (Assumed as part of Fuel Package)	1	EA		$ -	
7) New Electrical and Electrical Extension	1	EA	$ 133,000	$ 133,000	
Subtotal	149,001			$ 2,706,617	
Total for Vehicle Storage Building	**149,001**			**$ 2,706,617**	
2. Fleet Maintenance Facility					
1) Ventilation, Monitoring and Electrical Upgrade (Phase I)	40,000	SF	$ 35	$ 1,400,000	
Subtotal	40,000			$ 1,400,000	
Total for Vehicle Maintenance Facility	**40,000**	SF		**$ 1,400,000**	
			Subtotal Construction:	**$ 4,106,617**	
B. Site Demolition/Clearing					
1) Selective Demolition (External Panels in South Storage Bay)	34	EA	$ 1,180	$ 40,120	
			Subtotal Site Demolition and Clearing:	**$ 40,120**	
C. Site Development and Preparation					
1. Curb & Gutters	150	LF	$ 18	$ 2,700	
a. Asphaltic Concrete Base (6") and Surface (2") assumed	870	SY	$ 45	$ 39,150	
b. Concrete Paving		SY	$ 70	$ -	
2. Sidewalks	55	SY	$ 35	$ 1,925	
3. Landscaping Allowance	1	EA	$ 5,000	$ 5,000	
4. Fencing	500	LF	$ 20	$ 10,000	
5. Site Lighting					
a. Light Poles	2	EA	$ 5,000	$ 10,000	
b. U.G. Electrical	200	LF	$ 25	$ 5,000	
			Subtotal Site Development & Preparation Costs:	**$ 73,775**	
SUBTOTAL CONSTRUCTION COST: (Sum of A thru C)				**$ 4,220,512**	
D. Design Contingency (20% of A thru C)				$ 844,102	
E. Escalation (To 2013 Construction Start Date) (4% of A thru C)				$ 168,820	
TOTAL CNG PHASE I FACILITY CONVERSION COSTS: (Sum of A thru E)				**$ 5,233,435**	

DRAFT CNG Fueling Analysis - KCATA

(based on VICE Infrastructure Evaluation Model from DOE)

Basic Analysis Parmeters		
Assumed CNG bus order/yr		Varies
Miles per vehicle/yr. (KCATA)		35967
Analysis Start - two years in future		(2013)
Current Est. CNG cost / DGE (Sept. 2011)	$ 1.51	
Current Est. Diesel cost / DGE	$ 3.00	
Estimated Incremental Cost of CNG Bus	$ 50,000	

Federal Mandated Discount Rate =	3.0%
Salvage Value Determination; linear evaluation with 14 year useful life for buses	
CNG Price Escalation Rate per year =	0.3%
Diesel Escalation Rate per year =	1.8%

PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
BENEFITS SUMMARY															
No. of CNG Buses / year to be Purchased	0	25	25	20	20	20	20	20	20	20	20	20	20	10	9
Cumulative CNG bus total in fleet		25	50	70	90	110	130	150	170	190	210	230	250	260	269
Cumulative Milage for CNG Bus Fleet - KCATA	0	449588	1798350	2517690	3237030	3956370	4675710	5395050	6114390	6833730	7553070	8272410	8991750	9351420	9675123
Cumulative Milage for CNG Bus Fleet - all buses	0	449587.5	1798350	2517690	3237030	3956370	4675710	5395050	6114390	6833730	7553070	8272410	8991750	9351420	9675123
Diesel Cost/gal	$ 3.00	$ 3.05	$ 3.11	$ 3.16	$ 3.22	$ 3.28	$ 3.34	$ 3.40	$ 3.46	$ 3.52	$ 3.59	$ 3.65	$ 3.72	$ 3.78	$ 3.85
CNG Equiv. Cost/Gal (DGE basis)	$ 1.51	$ 1.51	$ 1.52	$ 1.52	$ 1.53	$ 1.53	$ 1.54	$ 1.54	$ 1.55	$ 1.55	$ 1.56	$ 1.56	$ 1.57	$ 1.57	$ 1.57
Diesel Gallons @ 4 MPG	-	112,397	449,588	629,423	809,258	989,093	1,168,928	1,348,763	1,528,598	1,708,433	1,888,268	2,068,103	2,247,938	2,337,855	2,418,781
CNG - DGE @ 3.28 MPG	-	137,069	548,277	767,588	986,899	1,206,210	1,425,521	1,644,832	1,864,143	2,083,454	2,302,765	2,522,076	2,741,387	2,851,043	2,949,733
Total Fuel Savings (DGE basis) Diesel costs	$ -	$ 135,664	$ 564,881	$ 822,559	$ 1,099,167	$ 1,395,258	$ 1,711,398	$ 2,048,165	$ 2,406,154	$ 2,785,972	$ 3,188,241	$ 3,613,600	$ 4,062,699	$ 4,368,200	$ 4,670,221
Undiscounted Benefit Value per Year	$ -	$ 135,664	$ 564,881	$ 822,559	$ 1,099,167	$ 1,395,258	$ 1,711,398	$ 2,048,165	$ 2,406,154	$ 2,785,972	$ 3,188,241	$ 3,613,600	$ 4,062,699	$ 4,368,200	$ 4,670,221
Discounted Benefit Value per year to Present	$ -	$ 131,713	$ 532,455	$ 752,758	$ 976,596	$ 1,203,562	$ 1,433,269	$ 1,665,346	$ 1,899,440	$ 2,135,216	$ 2,372,351	$ 2,610,541	$ 2,849,495	$ 2,974,532	$ 3,087,566
Discount Index	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766	0.744	0.722	0.701	0.681	0.661

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PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
COST SUMMARY with CNG FACILITY IMPROVEMENTS															
CNG Bus Cost (Delta)		$ 1,250,000	$ 1,250,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 500,000	$ 450,000
Electrical Upgrades/Gas Upgrades	$ 133,000	$ 133,000													
Bus Fueling Facility (includes canopy)	$ 1,630,000	$ 1,630,000	$ 50,000	$ 50,000	$ 500,000	$ 50,000	$ 50,000	$ 500,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Storage Building Modifications	$ 3,000,000	$ 2,000,000													
Maintenance Building Modifications	$ 450,000	$ 400,000			$ 250,000			$ 250,000							
Bus Wash Bay Modifications	$ 150,000	$ 100,000													
Site Reconfiguration/Pkg. (plumbing, grading, paving)	$ 250,000	$ 250,000													
Maintenance Equipment		$ 75,000	$ 25,000	$ 15,000											
Maintenance Training		$ 75,000	$ 25,000	$ 15,000											
Administration Costs	$ 150,000	$ 150,000													
Design Costs	$ 500,000	$ 500,000													
Additional Electricity Costs (in fuel number = $0.14/DGE))															
Undiscounted Cost Value per Year	$ 6,263,000	$ 6,563,000	$ 1,350,000	$ 1,080,000	$ 1,750,000	$ 1,050,000	$ 1,050,000	$ 1,750,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 550,000	$ 500,000
Discounted Cost Value per year to Present	$ 6,263,000	$ 6,371,845	$ 1,272,504	$ 988,353	$ 1,554,852	$ 905,739	$ 879,358	$ 1,422,910	$ 828,880	$ 804,738	$ 781,299	$ 758,542	$ 736,449	$ 374,523	$ 330,559

Total Est. Project Cost $ 12,634,845

ADDITIONAL BENEFITS															
Bus Age at Project Duration (years)		14	13	12	11	10	9	8	7	6	5	4	3	2	1
Bus Salvage Ratio at Project Duration		0.00	0.07	0.14	0.21	0.29	0.36	0.43	0.50	0.57	0.64	0.71	0.79	0.86	0.93
Aggregate Incremental Bus Value at Project Duration		$ -	$ 89,286	$ 142,857	$ 214,286	$ 285,714	$ 357,143	$ 428,571	$ 500,000	$ 571,429	$ 642,857	$ 714,286	$ 785,714	$ 428,571	$ 417,857
Discounted Incremental Bus Salvage Value (2013 Basis)		$ -	$ 84,160	$ 130,735	$ 190,390	$ 246,460	$ 299,102	$ 348,468	$ 394,705	$ 437,952	$ 478,346	$ 516,015	$ 551,084	$ 291,836	$ 276,253
Total Facility Upgrades		$ 10,126,000	$ -	$ -	$ 750,000	$ -	$ -	$ 750,000	$ -	$ -	$ -	$ -	$ -		
Salvage Ratio at Project Duration		0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
Aggregate Incremental Facility Value at Project Duration		$ 3,037,800	$ -	$ -	$ 337,500	$ -	$ -	$ 450,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Discounted Incremental Facility Value (2013 Basis)		$ 2,949,320	$ -	$ -	$ 299,864	$ -	$ -	$ 365,891	$ -	$ -	$ -	$ -	$ -	$ -	$ -

PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
NO BUILD OPTION															
COST SUMMARY WITH DIESEL VEHICLES ONLY															
Total Diesel miles per Year	4913360	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720
Total Diesel Gallons per Year	1228340	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680
Total Diesel Fuel Cost per Year	$ 3,685,020	$ 7,502,700.72	$ 7,637,749.33	$ 7,775,228.82	$ 7,915,182.94	$ 8,057,656.23	$ 8,202,694.04	$ 8,350,342.54	$ 8,500,648.70	$ 8,653,660.38	$ 8,809,426.27	$ 8,967,995.94	$ 9,129,419.87	$ 9,293,749.42	$ 9,461,036.91
Discounted Diesel Cost Value to the Present	$ 3,759,913	$ 7,284,175	$ 7,199,311	$ 7,115,436	$ 7,032,538	$ 6,950,605	$ 6,869,627	$ 6,789,593	$ 6,710,491	$ 6,632,310	$ 6,555,040	$ 6,478,671	$ 6,403,191	$ 6,328,591	$ 6,254,860

Project Benefit/Cost Analysis Summary

Project Duration	Calendar Year	Project - Present Value (2013 Dollars): Aggregate Costs	Discount Rate	Aggregate Benefits	Net Benefits	Present Value - No Build Option: Annual Costs	Cumulative Cost
0	2013	$ 6,263,000	3%	$ -	$ (6,263,000)	$ 3,759,913	$ 3,759,913
1	2014	$ 12,634,845	3%	$ 3,081,033	$ (9,553,811)	$ 7,284,175	$ 11,044,088
2	2015	$ 13,907,349	3%	$ 3,697,648	$ (10,209,701)	$ 7,199,311	$ 18,243,400
3	2016	$ 14,895,702	3%	$ 4,496,981	$ (10,398,722)	$ 7,115,436	$ 25,358,836
4	2017	$ 16,450,554	3%	$ 6,047,991	$ (10,402,563)	$ 7,032,538	$ 32,391,373
5	2018	$ 17,356,294	3%	$ 7,498,013	$ (9,858,281)	$ 6,950,605	$ 39,341,978
6	2019	$ 18,235,652	3%	$ 9,230,383	$ (9,005,269)	$ 6,869,627	$ 46,211,605
7	2020	$ 19,658,562	3%	$ 11,610,088	$ (8,048,474)	$ 6,789,593	$ 53,001,198
8	2021	$ 20,487,442	3%	$ 13,904,233	$ (6,583,209)	$ 6,710,491	$ 59,711,688
9	2022	$ 21,292,180	3%	$ 16,477,401	$ (4,814,778)	$ 6,632,310	$ 66,343,999
10	2023	$ 22,073,478	3%	$ 19,328,099	$ (2,745,380)	$ 6,555,040	$ 72,899,039
11	2024	$ 22,832,021	3%	$ 22,454,655	$ (377,366)	$ 6,478,671	$ 79,377,710
12	2025	$ 23,568,469	3%	$ 25,855,234	$ 2,286,765	$ 6,403,191	$ 85,780,902
13	2026	$ 23,942,993	3%	$ 29,121,602	$ 5,178,610	$ 6,328,591	$ 92,109,493
14	2027	$ 24,273,552	3%	$ 32,485,421	$ 8,211,870	$ 6,254,860	$ 98,364,353

Benefit / Cost Ratio for Project	1.34

for project duration of 14 years.

DRAFT CNG Fueling Analysis - KCATA

(based on VICE Infrastructure Evaluation Model from DOE)

TranSystems

Basic Analysis Parmeters		
Assumed CNG bus order/yr		Varies
Miles per vehicle/yr. (KCATA)		35967
Analysis Start - two years in future		(2013)
Current Est. CNG cost / DGE (Sept. 2011)	$	1.51
Current Est. Diesel cost / DGE	$	3.00
Estimated Incremental Cost of CNG Bus	$	50,000

Federal Mandated Discount Rate =	3.0%
Salvage Value Determination; linear evaluation with 14 year useful life for buses	
CNG Price Escalation Rate per year =	2.4%
Diesel Escalation Rate per year =	4.1%

PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
BENEFITS SUMMARY															
No. of CNG Buses / year to be Purchased	0	25	25	20	20	20	20	20	20	20	20	20	20	10	9
Cumulative CNG bus total in fleet		25	50	70	90	110	130	150	170	190	210	230	250	260	269
Cumulative Milage for CNG Bus Fleet - KCATA	0	449588	1798350	2517690	3237030	3956370	4675710	5395050	6114390	6833730	7553070	8272410	8991750	9351420	9675123
Cumulative Milage for CNG Bus Fleet - all buses	0	449587.5	1798350	2517690	3237030	3956370	4675710	5395050	6114390	6833730	7553070	8272410	8991750	9351420	9675123
Diesel Cost/gal	$ 3.00	$ 3.12	$ 3.25	$ 3.38	$ 3.52	$ 3.67	$ 3.82	$ 3.97	$ 4.14	$ 4.31	$ 4.48	$ 4.67	$ 4.86	$ 5.06	$ 5.27
CNG Equiv. Cost/Gal (DGE basis)	$ 1.51	$ 1.55	$ 1.58	$ 1.62	$ 1.66	$ 1.70	$ 1.74	$ 1.78	$ 1.83	$ 1.87	$ 1.91	$ 1.96	$ 2.01	$ 2.06	$ 2.10
Diesel Gallons @ 4 MPG	-	112,397	449,588	629,423	809,258	989,093	1,168,928	1,348,763	1,528,598	1,708,433	1,888,268	2,068,103	2,247,938	2,337,855	2,418,781
CNG - DGE @ 3.28 MPG	-	137,069	548,277	767,588	986,899	1,206,210	1,425,521	1,644,832	1,864,143	2,083,454	2,302,765	2,522,076	2,741,387	2,851,043	2,949,733
Total Fuel Savings (DGE basis) Diesel costs	$ -	$ 139,073	$ 593,513	$ 885,647	$ 1,212,578	$ 1,576,848	$ 1,981,153	$ 2,428,349	$ 2,921,461	$ 3,463,690	$ 4,058,425	$ 4,709,255	$ 5,419,971	$ 5,965,159	$ 6,527,747
Undiscounted Benefit Value per Year	$ -	$ 139,073	$ 593,513	$ 885,647	$ 1,212,578	$ 1,576,848	$ 1,981,153	$ 2,428,349	$ 2,921,461	$ 3,463,690	$ 4,058,425	$ 4,709,255	$ 5,419,971	$ 5,965,159	$ 6,527,747
Discounted Benefit Value per year to Present	$ -	$ 135,023	$ 559,443	$ 810,493	$ 1,077,360	$ 1,360,203	$ 1,659,184	$ 1,974,470	$ 2,306,228	$ 2,654,630	$ 3,019,850	$ 3,402,066	$ 3,801,459	$ 4,061,983	$ 4,315,610
Discount Index	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766	0.744	0.722	0.701	0.681	0.661
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PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
COST SUMMARY with CNG FACILITY IMPROVEMENTS															
CNG Bus Cost (Delta)		$ 1,250,000	$ 1,250,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 500,000	$ 450,000
Electrical Upgrades/Gas Upgrades	$ 133,000	$ 133,000													
Bus Fueling Facility (includes canopy)	$ 1,630,000	$ 1,630,000	$ 50,000	$ 50,000	$ 500,000	$ 50,000	$ 50,000	$ 500,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Storage Building Modifications	$ 3,000,000	$ 2,000,000													
Maintenance Building Modifications	$ 450,000	$ 400,000			$ 250,000			$ 250,000							
Bus Wash Bay Modifications	$ 150,000	$ 100,000													
Site Reconfiguration/Pkg. (plumbing, grading, paving)	$ 250,000	$ 250,000													
Maintenance Equipment		$ 75,000	$ 25,000	$ 15,000											
Maintenance Training		$ 75,000	$ 25,000	$ 15,000											
Administration Costs	$ 150,000	$ 150,000													
Design Costs	$ 500,000	$ 500,000													
Additional Electricity Costs (in fuel number = $0.14/DGE))															
Undiscounted Cost Value per Year	$ 6,263,000	$ 6,563,000	$ 1,350,000	$ 1,080,000	$ 1,750,000	$ 1,050,000	$ 1,050,000	$ 1,750,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 550,000	$ 500,000
Discounted Cost Value per year to Present	$ 6,263,000	$ 6,371,845	$ 1,272,504	$ 988,353	$ 1,554,852	$ 905,739	$ 879,358	$ 1,422,910	$ 828,880	$ 804,738	$ 781,299	$ 758,542	$ 736,449	$ 374,523	$ 330,559
Total Est. Project Cost	$ 12,634,845														

ADDITIONAL BENEFITS	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bus Age at Project Duration (years)	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Bus Salvage Ratio at Project Duration	0.00	0.07	0.14	0.21	0.29	0.36	0.43	0.50	0.57	0.64	0.71	0.79	0.86	0.93
Aggregate Incremental Bus Value at Project Duration	$ -	$ 89,286	$ 142,857	$ 214,286	$ 285,714	$ 357,143	$ 428,571	$ 500,000	$ 571,429	$ 642,857	$ 714,286	$ 785,714	$ 428,571	$ 417,857
Discounted Incremental Bus Salvage Value (2013 Basis)	$ -	$ 84,160	$ 130,735	$ 190,390	$ 246,460	$ 299,102	$ 348,468	$ 394,705	$ 437,952	$ 478,346	$ 516,015	$ 551,084	$ 291,836	$ 276,253
Total Facility Upgrades	$ 10,126,000	$ -	$ -	$ 750,000	$ -	$ -	$ 750,000	$ -	$ -	$ -	$ -	$ -		
Salvage Ratio at Project Duration	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
Aggregate Incremental Facility Value at Project Duration	$ 3,037,800	$ -	$ -	$ 337,500	$ -	$ -	$ 450,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Discounted Incremental Facility Value (2013 Basis)	$ 2,949,320	$ -	$ -	$ 299,864	$ -	$ -	$ 365,891	$ -	$ -	$ -	$ -	$ -	$ -	$ -

PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
NO BUILD OPTION															
COST SUMMARY WITH DIESEL VEHICLES ONLY															
Total Diesel miles per Year	4913360	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720
Total Diesel Gallons per Year	1228340	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680
Total Diesel Fuel Cost per Year	$ 3,685,020	$ 7,672,211.64	$ 7,986,772.32	$ 8,314,229.98	$ 8,655,113.41	$ 9,009,973.06	$ 9,379,381.96	$ 9,763,936.62	$ 10,164,258.02	$ 10,580,992.60	$ 11,014,813.29	$ 11,466,420.64	$ 11,936,543.88	$ 12,425,942.18	$ 12,935,405.81
Discounted Diesel Cost Value to the Present	$ 3,759,913	$ 7,448,749	$ 7,528,299	$ 7,608,698	$ 7,689,956	$ 7,772,082	$ 7,855,085	$ 7,938,974	$ 8,023,759	$ 8,109,450	$ 8,196,056	$ 8,283,586	$ 8,372,052	$ 8,461,462	$ 8,551,827

Project Benefit/Cost Analysis Summary

Project Duration	Calendar Year	Project - Present Value (2013 Dollars) Aggregate Costs	Discount Rate	Aggregate Benefits	Net Benefits	Present Value - No Build Option Annual Costs	Cumulative Cost
0	2013	$ 6,263,000	3%	$ -	$ (6,263,000)	$ 3,759,913	$ 3,759,913
1	2014	$ 12,634,845	3%	$ 3,084,343	$ (9,550,502)	$ 7,448,749	$ 11,208,662
2	2015	$ 13,907,349	3%	$ 3,727,947	$ (10,179,403)	$ 7,528,299	$ 18,736,961
3	2016	$ 14,895,702	3%	$ 4,585,014	$ (10,310,688)	$ 7,608,698	$ 26,345,659
4	2017	$ 16,450,554	3%	$ 6,236,788	$ (10,213,766)	$ 7,689,956	$ 34,035,615
5	2018	$ 17,356,294	3%	$ 7,843,451	$ (9,512,843)	$ 7,772,082	$ 41,807,697
6	2019	$ 18,235,652	3%	$ 9,801,736	$ (8,433,916)	$ 7,855,085	$ 49,662,782
7	2020	$ 19,658,562	3%	$ 12,490,565	$ (7,167,997)	$ 7,938,974	$ 57,601,756
8	2021	$ 20,487,442	3%	$ 15,191,498	$ (5,295,944)	$ 8,023,759	$ 65,625,515
9	2022	$ 21,292,180	3%	$ 18,284,080	$ (3,008,099)	$ 8,109,450	$ 73,734,965
10	2023	$ 22,073,478	3%	$ 21,782,276	$ (291,202)	$ 8,196,056	$ 81,931,021
11	2024	$ 22,832,021	3%	$ 25,700,357	$ 2,868,336	$ 8,283,586	$ 90,214,607
12	2025	$ 23,568,469	3%	$ 30,052,900	$ 6,484,431	$ 8,372,052	$ 98,586,659
13	2026	$ 23,942,993	3%	$ 34,406,719	$ 10,463,727	$ 8,461,462	$ 107,048,120
14	2027	$ 24,273,552	3%	$ 38,998,582	$ 14,725,030	$ 8,551,827	$ 115,599,948

Benefit / Cost Ratio for Project	1.61	for project duration of 14 years.

DRAFT CNG Fueling Analysis - KCATA

(based on VICE Infrastructure Evaluation Model from DOE)

Basic Analysis Parmeters	
Assumed CNG bus order/yr	Varies
Miles per vehicle/yr. (KCATA)	35967
Analysis Start - two years in future	(2013)
Current Est. CNG cost / DGE (Sept. 2011)	$ 1.51
Current Est. Diesel cost / DGE	$ 3.00
Estimated Incremental Cost of CNG Bus	$ 50,000

Federal Mandated Discount Rate =	3.0%
Salvage Value Determination; linear evaluation with 14 year useful life for buses	
CNG Price Escalation Rate per year =	4.5%
Diesel Escalation Rate per year =	6.4%

PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
BENEFITS SUMMARY															
No. of CNG Buses / year to be Purchased	0	25	25	20	20	20	20	20	20	20	20	20	20	10	9
Cumulative CNG bus total in fleet		25	50	70	90	110	130	150	170	190	210	230	250	260	269
Cumulative Milage for CNG Bus Fleet - KCATA	0	449588	1798350	2517690	3237030	3956370	4675710	5395050	6114390	6833730	7553070	8272410	8991750	9351420	9675123
Cumulative Milage for CNG Bus Fleet - all buses	0	449587.5	1798350	2517690	3237030	3956370	4675710	5395050	6114390	6833730	7553070	8272410	8991750	9351420	9675123
Diesel Cost/gal	$ 3.00	$ 3.19	$ 3.40	$ 3.61	$ 3.84	$ 4.09	$ 4.35	$ 4.63	$ 4.93	$ 5.24	$ 5.58	$ 5.94	$ 6.32	$ 6.72	$ 7.15
CNG Equiv. Cost/Gal (DGE basis)	$ 1.51	$ 1.58	$ 1.65	$ 1.72	$ 1.80	$ 1.88	$ 1.97	$ 2.05	$ 2.15	$ 2.24	$ 2.34	$ 2.45	$ 2.56	$ 2.68	$ 2.80
Diesel Gallons @ 4 MPG	-	112,397	449,588	629,423	809,258	989,093	1,168,928	1,348,763	1,528,598	1,708,433	1,888,268	2,068,103	2,247,938	2,337,855	2,418,781
CNG - DGE @ 3.28 MPG	-	137,069	548,277	767,588	986,899	1,206,210	1,425,521	1,644,832	1,864,143	2,083,454	2,302,765	2,522,076	2,741,387	2,851,043	2,949,733
Total Fuel Savings (DGE basis)	$ -	$ 142,482	$ 622,842	$ 951,835	$ 1,334,421	$ 1,776,609	$ 2,284,971	$ 2,866,696	$ 3,529,635	$ 4,282,364	$ 5,134,240	$ 6,095,472	$ 7,177,184	$ 8,080,701	$ 9,045,462
Diesel costs															
Undiscounted Benefit Value per Year	$ -	$ 142,482	$ 622,842	$ 951,835	$ 1,334,421	$ 1,776,609	$ 2,284,971	$ 2,866,696	$ 3,529,635	$ 4,282,364	$ 5,134,240	$ 6,095,472	$ 7,177,184	$ 8,080,701	$ 9,045,462
Discounted Benefit Value per year to Present	$ -	$ 138,332	$ 587,089	$ 871,063	$ 1,185,616	$ 1,532,518	$ 1,913,627	$ 2,330,886	$ 2,786,326	$ 3,282,075	$ 3,820,357	$ 4,403,499	$ 5,033,932	$ 5,502,565	$ 5,980,116
Discount Index	1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	0.789	0.766	0.744	0.722	0.701	0.681	0.661
					C										

PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
COST SUMMARY with CNG FACILITY IMPROVEMENTS															
CNG Bus Cost (Delta)		$ 1,250,000	$ 1,250,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 500,000	$ 450,000
Electrical Upgrades/Gas Upgrades	$ 133,000	$ 133,000													
Bus Fueling Facility (includes canopy)	$ 1,630,000	$ 1,630,000	$ 50,000	$ 50,000	$ 500,000	$ 50,000	$ 50,000	$ 500,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Storage Building Modifications	$ 3,000,000	$ 2,000,000													
Maintenance Building Modifications	$ 450,000	$ 400,000			$ 250,000			$ 250,000							
Bus Wash Bay Modifications	$ 150,000	$ 100,000													
Site Reconfiguration/Pkg. (plumbing, grading, paving)	$ 250,000	$ 250,000													
Maintenance Equipment		$ 75,000	$ 25,000	$ 15,000											
Maintenance Training		$ 75,000	$ 25,000	$ 15,000											
Administration Costs	$ 150,000	$ 150,000													
Design Costs	$ 500,000	$ 500,000													
Additional Electricity Costs (in fuel number = $0.14/DGE))															
Undiscounted Cost Value per Year	$ 6,263,000	$ 6,563,000	$ 1,350,000	$ 1,080,000	$ 1,750,000	$ 1,050,000	$ 1,050,000	$ 1,750,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 1,050,000	$ 550,000	$ 500,000
Discounted Cost Value per year to Present	$ 6,263,000	$ 6,371,845	$ 1,272,504	$ 988,353	$ 1,554,852	$ 905,739	$ 879,358	$ 1,422,910	$ 828,880	$ 804,738	$ 781,299	$ 758,542	$ 736,449	$ 374,523	$ 330,559

Total Est. Project Cost $ 12,634,845

ADDITIONAL BENEFITS	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bus Age at Project Duration (years)	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Bus Salvage Ratio at Project Duration	0.00	0.07	0.14	0.21	0.29	0.36	0.43	0.50	0.57	0.64	0.71	0.79	0.86	0.93
Aggregate Incremental Bus Value at Project Duration	$ -	$ 89,286	$ 142,857	$ 214,286	$ 285,714	$ 357,143	$ 428,571	$ 500,000	$ 571,429	$ 642,857	$ 714,286	$ 785,714	$ 428,571	$ 417,857
Discounted Incremental Bus Salvage Value (2013 Basis)	$ -	$ 84,160	$ 130,735	$ 190,390	$ 246,460	$ 299,102	$ 348,468	$ 394,705	$ 437,952	$ 478,346	$ 516,015	$ 551,084	$ 291,836	$ 276,253
Total Facility Upgrades	$ 10,126,000	$ -	$ -	$ 750,000	$ -	$ -	$ 750,000	$ -	$ -	$ -	$ -	$ -		
Salvage Ratio at Project Duration	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
Aggregate Incremental Facility Value at Project Duration	$ 3,037,800	$ -	$ -	$ 337,500	$ -	$ -	$ 450,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Discounted Incremental Facility Value (2013 Basis)	$ 2,949,320	$ -	$ -	$ 299,864	$ -	$ -	$ 365,891	$ -	$ -	$ -	$ -	$ -	$ -	$ -

PROJECT YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CALENDAR YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
NO BUILD OPTION															
COST SUMMARY WITH DIESEL VEHICLES ONLY															
Total Diesel miles per Year	4913360	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720	9826720
Total Diesel Gallons per Year	1228340	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680	2456680
Total Diesel Fuel Cost per Year	$ 3,685,020	$ 7,841,722.56	$ 8,343,592.80	$ 8,877,582.74	$ 9,445,748.04	$ 10,050,275.91	$ 10,693,493.57	$ 11,377,877.16	$ 12,106,061.30	$ 12,880,849.22	$ 13,705,223.57	$ 14,582,357.88	$ 15,515,628.78	$ 16,508,629.03	$ 17,565,181.28
Discounted Diesel Cost Value to the Present	$ 3,759,913	$ 7,613,323	$ 7,864,636	$ 8,124,246	$ 8,392,425	$ 8,669,456	$ 8,955,633	$ 9,251,255	$ 9,556,637	$ 9,872,098	$ 10,197,973	$ 10,534,606	$ 10,882,350	$ 11,241,573	$ 11,612,654

Project Benefit/Cost Analysis Summary

Project	Calendar	Project - Present Value (2013 Dollars)				Present Value - No Build Option	
Duration	Year	Aggregate Costs	Discount Rate	Aggregate Benefits	Net Benefits	Annual Costs	Cumulative Cost
0	2013	$ 6,263,000	3%	$ -	$ (6,263,000)	$ 3,759,913	$ 3,759,913
1	2014	$ 12,634,845	3%	$ 3,087,653	$ (9,547,192)	$ 7,613,323	$ 11,373,236
2	2015	$ 13,907,349	3%	$ 3,758,902	$ (10,148,448)	$ 7,864,636	$ 19,237,872
3	2016	$ 14,895,702	3%	$ 4,676,539	$ (10,219,163)	$ 8,124,246	$ 27,362,118
4	2017	$ 16,450,554	3%	$ 6,436,570	$ (10,013,985)	$ 8,392,425	$ 35,754,543
5	2018	$ 17,356,294	3%	$ 8,215,548	$ (9,140,746)	$ 8,669,456	$ 44,423,999
6	2019	$ 18,235,652	3%	$ 10,428,277	$ (7,807,376)	$ 8,955,633	$ 53,379,632
7	2020	$ 19,658,562	3%	$ 13,473,521	$ (6,185,041)	$ 9,251,255	$ 62,630,887
8	2021	$ 20,487,442	3%	$ 16,654,552	$ (3,832,890)	$ 9,556,637	$ 72,187,524
9	2022	$ 21,292,180	3%	$ 20,374,580	$ (917,600)	$ 9,872,098	$ 82,059,622
10	2023	$ 22,073,478	3%	$ 24,673,283	$ 2,599,805	$ 10,197,973	$ 92,257,595
11	2024	$ 22,832,021	3%	$ 29,592,797	$ 6,760,776	$ 10,534,606	$ 102,792,201
12	2025	$ 23,568,469	3%	$ 35,177,813	$ 11,609,344	$ 10,882,350	$ 113,674,551
13	2026	$ 23,942,993	3%	$ 40,972,214	$ 17,029,221	$ 11,241,573	$ 124,916,124
14	2027	$ 24,273,552	3%	$ 47,228,583	$ 22,955,031	$ 11,612,654	$ 136,528,778

Benefit / Cost Ratio for Project	1.95

for project duration of 14 years.