

GREEN vs. GREEN

Alternative Fuels and Energy Efficiency in Scottsdale



By:

Kyle Hoopes

Daisy De La Rosa

Nicole Sonnenburg

Siddharth Mazumdar



TABLE OF CONTENTS

1. Executive Summary	3
2. Introduction.....	3
3. Alternative Fuel Conversion in Municipal Fleet.....	4
a. Case for Alternative Fuels in Municipal Fleet.....	4
b. Current Scenario	4
c. Comparable Cities Case Studies	6
i. Tempe	6
ii. Phoenix	6
iii. Denver	6
d. U.S. Department of Energy Report	7
e. Recommendations	10
4. Energy Efficiency in Municipal Buildings	11
a. Current Practices	11
b. Review Process	11
i. Energy Use	11
ii. Infrastructure	12
c. Recommendations	13
5. References	15

Executive Summary

This document is the result of a collaboration between the City of Scottsdale, hereafter referred to as Scottsdale, and the School of Sustainability at Arizona State University. The primary purpose of this project is twofold: 1) to provide researched information for Scottsdale to assess potential impacts of converting all solid waste fleet vehicles to alternative fuels, primarily CNG, and 2) to provide suggestions for energy efficiency in municipal buildings. The study entails a baseline analysis of Scottsdale's current fleet operations and compares it with other comparable cities and their current practices with regards to fleet conversion to alternative fuels. From the energy efficiency perspective, current energy usage was analyzed in eight municipal buildings to determine cost savings from infrastructure improvements like metering and installation of efficient HVAC systems.

2. Introduction

Founded in 1894 by Winfield Scott, the City of Scottsdale has grown from 2000 people in 1951 to an estimated 242,000 in 2017. Situated in the Sonoran Desert, it is bordered by Phoenix to the west and the McDowell Mountains to the east. The city is loosely divided into four areas which are South Scottsdale, Old Town Scottsdale, Central Scottsdale and North Scottsdale, which all offer unique activities. Recognized for scenic views, the city is rated among the nation's most desirable communities to live in. Furthermore, the city's initiatives are also directed towards transforming into a highly sustainable modern community.

As a prosperous big urban city, Scottsdale has multiple avenues to incorporate sustainability into its operations and services. It has already made great advances in fleet management and the transportation sector. In particular, the city is committed to improving transportation, with focus on its municipal fleet. The fleet is highly diversified and operates with diverse fuel types: 276 vehicles operate on diesel, 49 on compressed natural gas (CNG), 11 are electric vehicles, and others operate on different alternative fuels. Given the city's high fuel consumption, most of the city's solid waste trucks operate on CNG. Investments in alternate fuels coupled with the purchase of flex fuel vehicles for government use, have had a potentially positive impact on the environment. This report attempts to study the economic costs and benefits of transitioning fleet vehicles to CNG across selected cities to provide comparative analysis of such policies for Scottsdale.

In addition, Scottsdale aspires to improve the energy efficiency of its built environment. They have recently implemented energy efficient HVAC systems and tankless water heaters.

However, many municipal buildings have only one meter for measuring energy usage. Consequently, the energy loads of different (sections), such as lights, AC and water, are not being tracked, making it increasingly difficult to determine the effectiveness of energy efficient improvements. This document makes preliminary suggestions regarding better energy management through options like sub metering and energy auditing in municipal buildings.

3. Alternative Fuel Conversion in Municipal Fleet

a. CASE FOR ALTERNATIVE FUELS IN MUNICIPAL FLEET

Transportation is a critical operation throughout the life cycle of any process or service. For municipal operations, transportation, whether it be mobilizing people or managing solid waste, has significant environmental, social and economic impacts. These impacts can be quantified using various indicators such as fuel consumption, amortization, capital, demand and labor, and, in turn help quantify (un)sustainability measures such as environmental impact, cost per ton as well as mileage, effect of heavy vehicles on roads, and air quality. The analysis below presents a case for one such parameter - the choice of fuel – which can have huge impacts due to the sheer scale of operations at the municipal level.

b. CURRENT SCENARIO

(Note – this section provides a condensed version of an accompanying separate Report analyzing fuel type).

The city’s fleet operates on a diverse set of fuels including diesel, B-20 (Bio diesel), CNG, and E85. The solid waste trucks, which are the focus of this document, have high fuel consumption due to higher vehicle miles travelled (VMT), lower mileage per gallon (3 – 4 miles per gallon), and their increasing likelihood to operate on alternative fuels, like CNG. This report focuses on the comparison of diesel and CNG for these vehicles. Scottsdale has also invested in supporting infrastructure around alternative fuels by building fueling stations for all types. However, this report will not be covering the costs of fueling stations.

Table 1. Scottsdale - Quantity of solid waste trucks based on vehicle and fuel type

	Diesel	CNG
Front Loader	4	4
Side Loader	13	17
Rear Loader	4	7
Total	21	28

CNG has emerged as a prominent choice when it comes to alternative fuels but still many of the fleet vehicles for most cities continue to run on diesel. While CNG vehicles mitigate environmental concerns, and provide long term economic benefits, they come with challenges such as higher capital costs and therefore it is important to perform a comparison across a comprehensive set of parameters given below.

BUYING COST

Scottsdale has 49 refuse trucks of which 21 are run on diesel while the rest (28) operate on CNG. According to three sources (Lemmons, 2009, Andrews, 2009, & San Antonio, 2009), the incremental cost of a CNG refuse truck is \$30,295 (Johnson, 2010) and therefore an investment of \$636,195 would be required to convert the entire fleet into CNG.

OPERATIONAL COST

“Maintenance and operation costs for a CNG bus are considered the same as those for a diesel bus because evidence supports both a cost decrease (Chandler et. al 2006) and a cost increase (CVEF 2010) when switching from CNG to diesel. The unclear cost signal portrayed in these studies represents a factor that is in flux due to maintenance learning curves, new diesel emissions equipment, a sub-competitive CNG parts market, and other factors. This cost parity for CNG buses is assumed to apply to CNG refuse trucks as well, which is supported by Engle (2010). In 2010 the maintenance costs for a CNG fleet were \$1.122/mile versus a diesel fleet cost of \$0.072/mile before 2010” (Johnson, 2010).

TIMEFRAME FOR CONVERSION

It is vital to gradually phase out diesel vehicles and not convert the entire fleet to CNG simultaneously due to a number of factors. Budget constraints need to be accounted for during diesel to CNG conversion given the high differential cost between the two types of trucks. Also, trucks built in with CNG engines are preferred over conversions as the former have a better ROI over their life compared to the later which have already been in service for several years. From the perspective of skilled labor, the city might not have trained staff or space to handle new inventory and add decals to vehicles if all changed at once. Finally, simultaneous procurement of CNG vehicles would mean that the lifetimes of all fleet vehicles would end at the same time requiring huge investments at the time of replacement.

MARKET FACTORS

United States has a significant reservoir of natural gas and a very good distribution system which keeps the prices of CNG low. Historically, CNG fuel prices have been relatively stable and low over several years, while diesel fuel prices have been relatively volatile over several years.

c. COMPARABLE CITIES CASE STUDIES

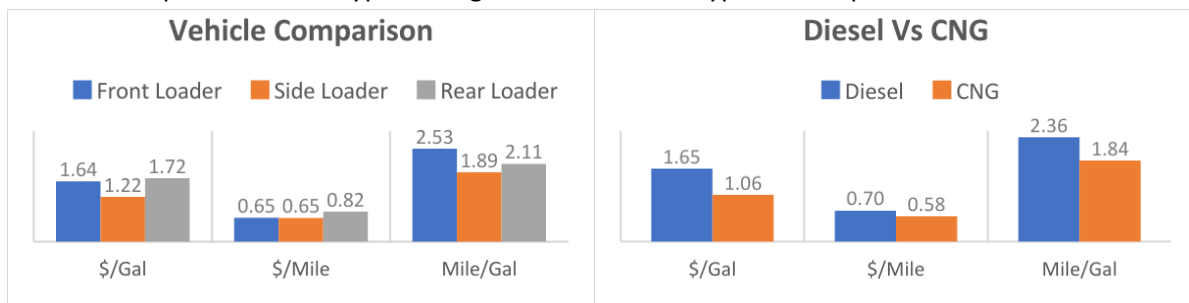
(Note – this section provides a condensed version of an accompanying separate Report analyzing fuel type).

This report will now analyze case studies from the cities of Tempe, Phoenix and Denver to highlight the portfolio of vehicles and fuel types employed in their fleets and critically study the pros and cons of conversion from diesel to CNG trucks.

CITY OF TEMPE

The City of Tempe which is Scottsdale’s neighbor to the south has a population of 182,498. Tempe’s fleet is heavily comprised of side loaders and front loaders along with a few rear loaders. Table 2 compares the different types of vehicles, based on models and types of fuel, from a cost perspective. The cost per mile and cost per gallon were lowest for the side loaders but these vehicles also had lower mileage when compared to the other categories of trucks. Also, CNG trucks fared better in comparison to diesel trucks by reducing cost per mile by 20% and cost per gallons by 36%.

Table 2: Comparison of fuel type among solid waste truck types in Tempe



CITY OF PHOENIX

The City of Phoenix has a population of 1.6 million. It has implemented major initiatives with regards to transitioning to alternative fuels for its vehicles such as installing more ethanol flex fuel tanks and sites. Also, as their budgets and policies allow, current solid waste diesel powered trucks at the end of their lifecycles are being replaced with CNG units supported by the four existing slow fill fuel sites. There is also a 5-year plan for transition to Ethanol (E54). The strategy being followed by Phoenix is utilizing CNG for large trucks that use significant amount of fuel: ethanol for light duty ones and hybrids for other vehicles.

CITY OF DENVER

The City of Denver, Colorado, with a population of 686,545 conducted an extensive study on its municipal fleet, which showed that their total fleet was composed of 1098 vehicles and within those vehicles there was 198 vehicle classes. Out of their whole fleet, 491 vehicles as well as 16 vehicle classes were identified for possible CNG replacements (DMCCC, n.d.). The average

mileage for the trucks in the Denver fleet is 5,466 miles per year, and the study showed that there are better returns on trucks that used more miles (DMCCC, n.d.). The study also highlighted that when the fuel price was \$1.55 per gasoline gallon which is equivalent for CNG, 259 vehicles (in 38 vehicles classified) would get paybacks without any grants or incentives. The return on investment would be in 5 years with an average saving of \$3,486 per vehicle (DMCCC, n.d.). The study also showed that that cumulative savings per vehicle over a lifetime was \$429,555, which was based on the CNG tank configuration. As for the top ten vehicle classes, the study done by the city of Denver showed that the total operation cost savings is \$286,743 (DMCCC, n.d.).

When it comes to converting to CNG, Denver offers incentives to those considering alternative fuels. For one, Denver offers grants to compensate for the incremental price of CNG vehicles. Another incentive for converting to CNG is that about 93% of classes would see paybacks over their lifetime. However, certain things have to be taken into consideration, like the fact that the main contributing factors to savings are cheap fuel price and energy density of CNG and gasoline. The Denver case study showed that converting to CNG can come with some problems. One being that CNG infrastructure can be very expensive, and building a new fast fill station could cost anywhere between 1 to 2 million dollars. In addition, CNG vehicles must meet NFPA standards, and the maintenance that is required for CNG vehicles is costly (DMCCC, n.d.).

While there are some problems that arose when considering converting to CNG, Denver also provided some possible solutions. One would be outsourcing to CNG developers. While this would increase the cost of fuel, it would avoid the capital cost required to build a fueling station. Also, maintenance for upgrades on vehicles can be done in existing facilities or can be contracted out to avoid costs. Since CNG vehicles are environmentally friendly, EPA certification requirements do not have to be met, which implies savings in emission reduction technologies. Lastly, the Alternative Fuel Colorado Grant Program offers up to \$500,000 which would help Denver cover a large portion of the initial investment capital (DMCCC, n.d.).

d. U.S. DEPARTMENT OF ENERGY REPORT

This section of the report will look at an analysis conducted by the U.S. Department of Energy, to help fleet managers determine the economic viability of converting their fleet and infrastructure to CNG fuel. Even though the analysis looked at both infrastructure and vehicles, this report focuses on the analysis of the vehicles.

BUSINESS CASE FOR CNG IN MUNICIPAL FLEETS

In 2010 the National Renewable Energy Laboratory (NREL) from the U.S. Department of Energy used the VICE Model (CNG Vehicle and Infrastructure Cash-Flow Evaluation) to analyze the profitability of converting municipal fleets to CNG. The VICE Model is a financial tool created

by the NREL to help fleet managers determine the financial soundness of converting their fleet vehicles to CNG. They created a base-case scenario for three fleet vehicle types: 1) transit buses, 2) school buses, and 3) refuse trucks (Johnson, 2010).

Through their analysis they were able to determine on average “...larger transit and refuse fleets (75+ vehicles) tend to be profitable and resilient to variations in project parameters. Their payback period only rises above 5 years when diesel drops below \$2.25/gallon, vehicle incremental costs are doubled, CNG vehicle maintenance costs increase 50%, VMT drops below 26,000 miles/year (transit) or 14,000 miles a year (refuse), vehicle incremental costs are doubled, or when these factors combine” (Johnson, 2010: 27). The data on the payback period for the three vehicle types in relation to diesel prices is shown in Graph 1.

Graph 1: Relationship between diesel price and payback period

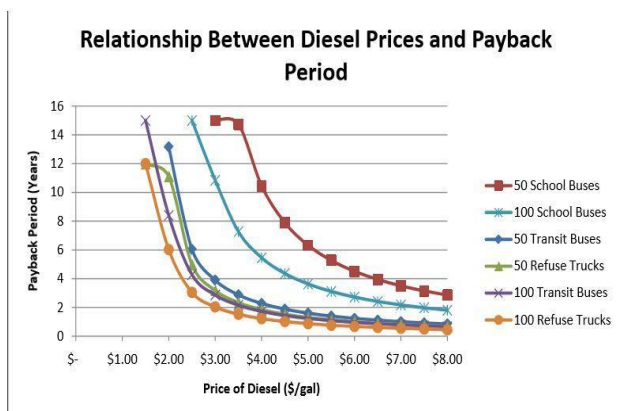


Figure 10. Relationship between diesel prices and payback period

Source: National Renewable Energy Lab

When analyzing the economic advantages of converting school buses, transit buses and refuse trucks to CNG, it is important to note from the report that a school bus fleet run on CNG only makes economic sense if the diesel prices rise above \$5 per gallon. However, for transit and refuse vehicles if diesel prices decrease below \$2.50 per gallon, larger fleets are favored to offset the costs. If diesel prices increase above \$2.50 per gallon then these vehicle types become very profitable if converted to CNG (Johnson, 2010). Throughout the analysis school bus fleets as the only CNG vehicle do not show high profitability. However, when they are joined with one or more vehicle types that run on CNG fuel, a fleet can capitalize on the economic advantages while minimizing the disadvantages, making CNG school fleet more reasonable (Johnson, 2010). For example, the advantages of having school buses, transit buses and refuse trucks that all run on CNG had more economic advantages than if a fleet only had one vehicle type run on CNG.

In Graphs 2a and 2b, NREL analysis was also able to determine that on average the payback period decreased and the rate of return increased as the fleet size increased.

Graph 2a & 2b: Rate of return by fleet size and types and payback period by fleet size

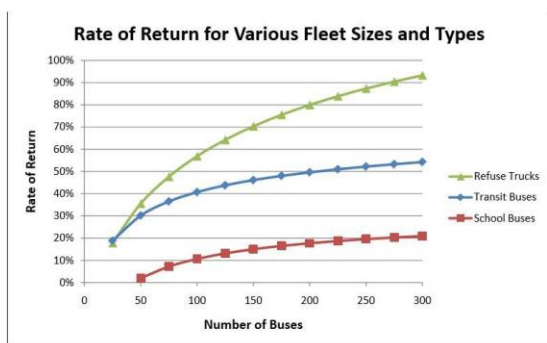


Figure 7. Rate of return for various fleet sizes and types

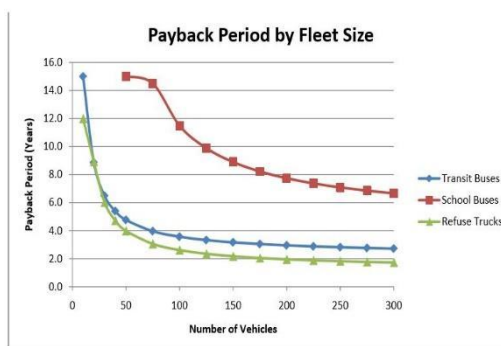


Figure 6. Payback period by fleet size

Source: National Renewable Energy Lab

This analysis considered government subsidies and tax credits that encourage the use of CNG. Table 3 shows the impacts of various tax credits on the payback period for the three vehicle types.

Table 3. Payback Period (Years) with Various Tax Credits Missing

Fleet (100 Vehicles)	All Credits	No Fuel Credit	No Vehicle Credit	No Station Credit	No Credits
Transit Buses	3.6	5.9	5.5	3.6	9.1
School Buses	11.5	≥15.0	≥15.0	11.8	≥15.0
Refuse Trucks	2.6	4.6	4.8	2.7	7.8

Source: National Renewable Energy Lab

In Table 3 the analysis took into consideration federal fuel credits, CNG vehicle credits and CNG station credits. If a fleet has all three credit types, the payback period can be reduced. Regarding refuse trucks the payback period in years can range from 7.8 years, with no credits, to 2.6 years, with the three credit types. To improve the profitability of conversion to CNG and other alternative fuels in municipal fleets, applying for tax credits from the federal government may be beneficial to the City of Scottsdale.

e. RECOMENDATIONS

Recommendations for the City of Scottsdale in their goal of fleet conversion to CNG fuel is based on the analysis of city case studies and the NREL analysis.

1. Converting to compressed natural gas can be economically viable for the municipal fleet. To reap the maximum benefits of the conversion, we recommend conducting the conversion slowly through attrition. **Gradually phasing out diesel vehicles for CNG at the end of the vehicles life cycle is more economically viable** in comparison to complete conversion all at one time because of several reasons. First would be possible budget restraints. The capital costs of alternative fuel vehicles tend to be higher than the common diesel vehicles. Gradual conversion will also allow maintenance personnel to learn the new engines and reduce mechanical errors in the long run. Secondly the life cycles of the vehicles will end relatively all at the same time which will increase capital costs.

2. The City of Scottsdale should not make CNG modification to their diesel vehicles. This will lead to a possibility of minimal to no payback because the modification does not increase the lifetime of the vehicle. There is also no warranty that comes with the CNG modification, unlike with the new CNG vehicles. **Larger transit and refuse fleets (75+) that are run on CNG tend to be more profitable and resilient to costs and market changes.**

3. The City of Scottsdale is interested in converting their entire fleet to CNG vehicles, due to its environmental benefits and popularity among municipal fleets. However, we recommend maintaining diversity of fuel types within the fleet. The fuel diversity increases fleet resiliency to market forces and unforeseeable disasters. It is also important to note that different vehicle types run more efficiently on different fuel types. Large buses and trucks that use a lot of fuel and run the same routes tend to be better suited for CNG and LNG (propane). Vans and vocational trucks tend to be better suited for biodiesel and electric hybrids. While smaller vehicles, like administrative cars and police vehicles, that are not used very often or travel fewer miles, tend to be better suited for electric or hybrids.

4. The City of Scottsdale should apply for federal tax credits for the use of alternative fuels. These tax credits can reduce the payback period of many CNG vehicles.

5. As the city continues to convert to CNG and other alternative fuels, the newer CNG solid waste trucks should be scheduled on the longer pick-up routes over the older diesel solid waste trucks to take advantage of the better mileage and fuel efficiency.

4. Energy Efficiency in Municipal Buildings

This section focuses on energy efficiency improvements for the City of Scottsdale.

a. CURRENT PRACTICES

The City of Scottsdale is invested in improving the overall energy efficiency of their public buildings. As part of this effort, they have explored ideas such as reducing their water, heating, and electrical costs by implementing tank-less water heaters where applicable. The city has also explored moving to more efficient HVAC systems which they could utilize by integrating them into their environmental controls systems. Lastly, Scottsdale wants to improve their overall efficiency and sustainability standing by trying to make as many of their public buildings LEED certified which will allow them the ability to garner better overall control. These goals are tied to the city's ability to better monitor their energy usage and the desire to decrease that overall energy usage, improve their energy efficiency, and decrease overall cost associated with energy consumption.

b. REVIEW PROCESS

As part of the initial review, the city's current energy practices were examined to help the City of Scottsdale determine what would be the best allocation of their resources to reach their goals and to determine potential savings. This process included interviewing current city employees to determine how they perceived their energy efficiency, reviewing the last seven years' energy statements, and reviewing how recent HVAC and tankless water heater upgrades affected the amount of energy used. These efforts implemented by the city, combined with improvements in overall reductions in energy usage, better management of energy resources, and self-identified areas of improvement have resulted in an annual decline in both total energy utilized and costs.

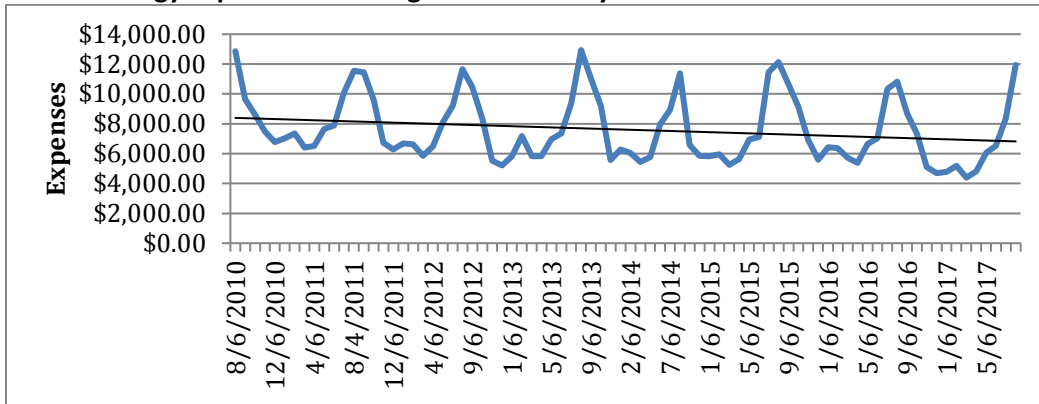
Additionally, Scottsdale already has implemented a large scale Environmental Management System (EMS) which has allowed the city to monitor all energy consumption, potential outages, and total energy usage across all of their building. The EMS remotely monitors individual sites in real time and determines if there has been a disruption to services, such as a malfunctioning HVAC system or a loss of power. This ability makes the city much more dynamic and allows them to address concerns in a timely and effective manner. The city has the capabilities to assess what is happening at a macro level due to the metering system that is currently employed by the city. However, there is a limitation within their current system in individual aspects of a location's energy profile cannot currently be determined. The inability to determine individual energy usage amongst multiple systems creates a pain point concerning the ability to see how energy is being utilized on a micro level.

ENERGY USE

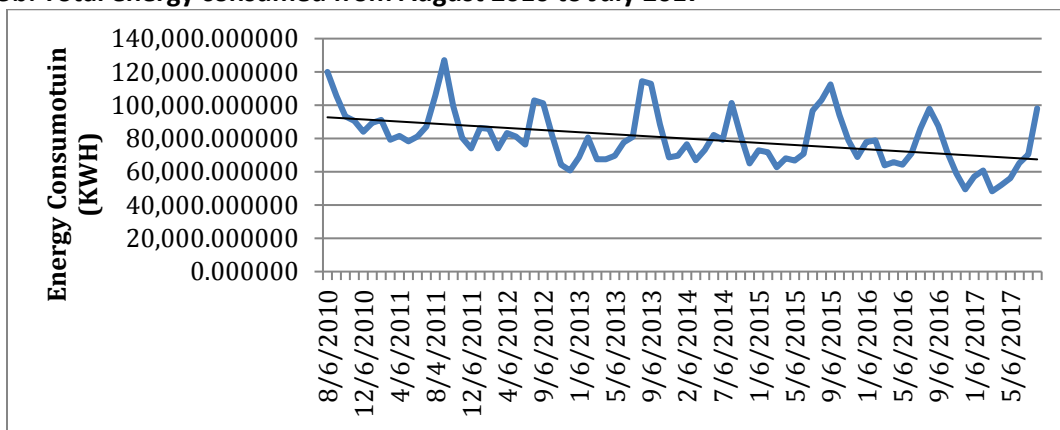
By focusing on improving their overall energy consumption over the past seven years, the city has achieved significant reduction in both the cost of their energy and energy usage. Graph 3a showcases the overall reduction in expenses from 2010 to 2017. Graph 3b demonstrates the

reduction in energy consumption over the same time frame. This trend has contributed to improvements in upgrading of current infrastructure to more energy efficient systems, investments in more efficient HVAC systems as well as into their Environmental Management System.

Graph 3a: Total energy expenses from August 2010 to July 2017



Graph 3b: Total energy consumed from August 2010 to July 2017



These improvements and changes have resulted in a marginal decrease in overall expenses but a significant decrease in overall consumption.

INFRASTRUCTURE

There are eight buildings that utilize significant amounts of energy in the municipality. However, there is a lack of detailed data regarding the makeup of the energy profile of these buildings. The eight identified locations are Indian School Park, Cactus Park, Chaparral Park, Eldorado Park, Mountain View Park, Paiute, Scottsdale Ranch Park, and Grayhawk Park. Each of these locations have identifiable areas that could potentially benefit from improvements in energy efficiency. Each of these building utilizes multiple big energy consumers but each site is on a single meter, which prevents any form of detailed analysis (see Table 4). Each of these locations has potential for cost savings and improvements in energy effectiveness if there was a way to differentiate how the energy is being utilized.

Table 4: Municipal Infrastructure energy profiles

<i>Location</i>	<i>Concern</i>
<i>Cactus Park</i>	<i>One meter, no meter on the pump house</i>
<i>Chaparral Park</i>	<i>No meter on the ballfield lights</i>
<i>Eldorado Park</i>	<i>No meter on the Boys and Girls Club</i>
<i>Mtn View Park</i>	<i>No meter on the ballfields</i>
<i>Paiute</i>	<i>Eight buildings one meter only, city rents out two of the buildings</i>
<i>Scottsdale Ranch Park</i>	<i>No meter on the tennis court lights</i>
<i>Grayhawk Park</i>	<i>No meter for either the tennis courts or the ballfield lights</i>
<i>Indian School Park</i>	<i>Only metered on Club Sar and the Giants Training Center</i>

c. RECOMENDATIONS

As Scottsdale is committed to improving their overall energy efficiency, improving their energy resiliency, and improving their energy sustainability, we recommend that the City of Scottsdale consider the following measures to increase energy performance:

- 1 Explore options to install **sub-meters on several of the locations**, mentioned previously. By sub-metering, the City of Scottsdale will be able to better monitor energy consumption, and with the improved data, the city can make more informed decisions regarding future energy policies and upgrades.
- 2 There are two different recommendations regarding the sub-metering of the City of Scottsdale.
 - a. The first is to contract with either *Climatec* Company which will provide an investment grade analysis of the city’s current energy needs or another well-known company *Trane* which will provide a Tier 2 energy review. Both companies offer competitive advantages to improving the level of monitoring for the City of Scottsdale. The advantages of partnering with either *Climatec* or *Trane* is that the city receives a detailed outline of what options are needed to meet expected goals for energy efficiency. The energy audits conducted by *Climatec* or *Trane* are free and can be utilized to determine areas of opportunity without having to invest in expensive equipment or processes. Additionally, if adopted, many of these plans have guaranteed returns of investments, long-term and short-term goals, checkpoints, and investment grade audits that can be used to either raise money or assure investors. The disadvantages of this option are that if a plan is selected then that process will be handled by a third party and the city will have to contract with either *Climatec* or *Trane* to achieve full implementation of their recommendations.

- b. The second recommendation would be to install sub-meters at each of the locations utilizing current city resources. The advantages of this option are that everything can be handled in house and would allow the city more autonomy regarding how it chooses to implement their energy policies. However, the disadvantages of this option are that many buildings were not designed to allow for either sub-metering or for a higher level of monitoring. There could be significant and unseen cost associated with this option. It is important for the City of Scottsdale to determine these possible costs and determine the best action for Scottsdale.

As mentioned in two separate section, this report is also accompanied by a separate document with more detailed analysis of the fuel types.

References

City of Scottsdale. (n.d) "West's Most Western Town." Retrieved from www.scottsdaleaz.gov/about/history.

City of Scottsdale. (n.d.). *About Scottsdale*. Retrieved from <http://www.scottsdaleaz.gov/about>

DMCCC (n.d.) *Clean Cities Fleet Audit Report*. Denver, Colorado.

Johnson, Caley (2010). *Business Case for Compressed Natural Gas in Municipal Fleet*. National Renewable Energy Laboratory. USDE.

Mountains in Scottsdale [online image] retrieved from <http://beginwithinscottsdale.com/fun-family-outings-to-do-around-scottsdale/>