Energy Efficiency and Diversification Evaluation

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City of Joplin, Missouri

Energy Efficiency and Diversification Evaluation
Project No. 139257

Revision 0
11/30/2022

Energy Efficiency and Diversification Evaluation

prepared for

City of Joplin, Missouri
Energy Efficiency and Diversification Evaluation

Project No. 139257

Revision 0
11/30/2022

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

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TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION 1-1
1.1 Summary of Findings 1-1

2.0 UTILITY PROVIDER RESOURCE MIX 2-1
2.1 Electricity Provider: Algonquin-Liberty 2-1
2.2 Natural Gas Provider: Spire 2-2

3.0 MUNICIPAL FACILITIES ENERGY CONSUMPTION 3-1
3.1 Methodology 3-1
3.2 Facilities Energy Consumption 3-1
3.3 Facilities Energy Use Intensity 3-3
3.3.1 Energy Star Benchmarking 3-4
3.4 Facilities Evaluation 3-4
3.5 Key Findings and Opportunities 3-5

4.0 FLEET FUEL CONSUMPTION 4-1
4.1 Methodology 4-1
4.2 Fuel Consumption 4-1
4.3 Fleet Operations Evaluation 4-3
4.4 Key Findings and Opportunities 4-7

5.0 WWTP ENERGY USAGE 5-1
5.1 Methodology 5-1
5.2 WWTP Energy Usage 5-1
5.3 WWTP Evaluation 5-2
5.4 Anaerobic Digestion and Renewable Gas 5-2
5.5 Key Findings and Opportunities 5-3

APPENDIX A – ENERGY CONSUMPTION FOR MUNICIPAL FACILITIES
APPENDIX B – FLEET INVENTORY BY DEPARTMENT

DRAFT

LIST OF TABLES

Page No.

Table 3-1: Energy Star Conversion Factors 3-1
Table 4-1: Fleet Data by Department – FY 2021 4-1
Table 5-1: Annual WWTP Energy Consumption 5-1

DRAFT

LIST OF FIGURES

Page No.

Figure 2-1: Algonquin-Liberty 2020 Resource Mix by Capacity and Generation 2-2
Figure 3-1: Combined Electricity and Natural Gas Energy Consumption for Facilities in 2021 (kBtu) 3-2
Figure 3-2: Electricity and Natural Gas Energy Consumption by Municipal Facilities in 2021 3-3
Figure 3-3: Energy Use Intensity for Municipal Facilities in 2021 3-4
Figure 4-1: Total Fuel Consumed Per Department in FY 2021 4-3
Figure 4-2: Vehicle Count by Type 4-4
Figure 4-3: Average Age by Vehicle Type 4-5
Figure 5-1: 2021 WWTP Energy Consumption 5-2

DRAFT

LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
Algonquin-Liberty	Algonquin-Liberty Power & Utilities Corporation
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CCF	Hundreds of Cubic Feet
City	City of Joplin, Missouri
CNG	Compressed natural gas
ECDs	Eddy-current drives
EUI	Energy Use Intensity
EVs	Electric Vehicles
FY	Fiscal Year
GWh	Gigawatt hours
HEVs	Hybrid-electric vehicles
HVAC	Heating, ventilation and air conditioning
kBtu	Thousand British Thermal Units
kWh	Kilowatt Hours
MAPS	Metro Area Public Transit System
MGD	Million gallons per day
MPG	Miles per gallon
MW	Megawatts
RNG	Renewable Natural Gas
Spire	Spire Inc.
SUV	Sport Utility vehicle

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Abbreviation	Term/Phrase/Name
U.S. EPA	U.S. Environmental Protection Agency
VFDs	Variable-frequency drives
WIC	Women, Infant and Children
WWTP	Wastewater Treatment Plant

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1.0 INTRODUCTION

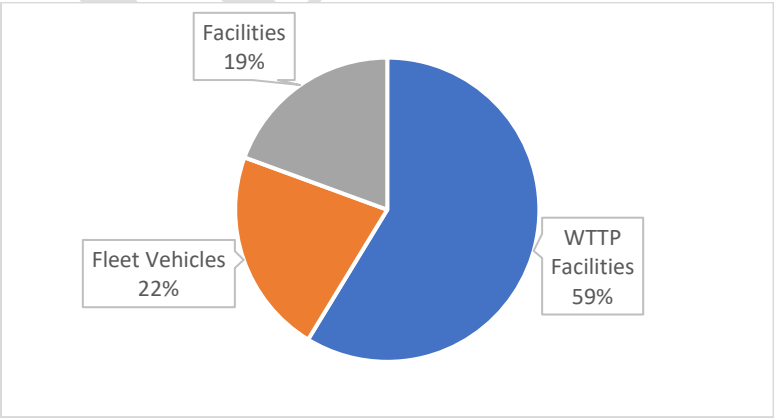
Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) performed an evaluation of the operational energy use matrix and identified opportunities to reduce energy use and diversify energy sources for the City of Joplin, Missouri (City). For this evaluation, Burns & McDonnell completed the following activities:

- Reviewed the City's current energy sources and usage where readily available from municipal facilities, fleet, and wastewater treatment plant (WWTP) operations to benchmark the current matrix; and
- Performed a high-level evaluation to identify opportunities for increasing energy efficiency and investing in renewable energy.

1.1 Summary of Findings

This evaluation includes the energy consumption for 13 City-selected facilities, 238 fleet vehicles, two WWTPs and one lift station. The city annually consumes approximately 115 million thousand British thermal units (kBtu) of energy across its facilities, fleet vehicles, WWTP facilities based on data included in this evaluation. As illustrated in Figure 1-1, WWTP operations represents the largest energy consumer for the City. WWTP facilities consumed 67,786,756 kBtu, fleet vehicles consumed 25,253,249 kBtu, and facilities consumed 22,405,743 kBtu. WWTPs are generally the largest consumer of energy for many municipalities; therefore, WWTP operations present the greatest opportunity to reduce energy consumption, energy costs, and emissions.

Figure 1-1: City's Energy Consumption Breakdown



Within each area evaluated there are opportuniteis for improving the energy efficiency and diversifying energy sources utilized.

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2.0 UTILITY PROVIDER RESOURCE MIX

The City utilizes two providers for their electricity and natural gas usage: Algonquin-Liberty Power & Utilities Corporation (Algonquin-Liberty) and Spire Inc (Spire). Understanding an energy provider's current and projected resource mix provides valuable information for assessing the extent of the City's energy diversification

2.1 Electricity Provider: Algonquin-Liberty

The City's electricity is provided by Algonquin-Liberty. They have a resource mix for generating electricity, which as of 2020, consists of 51percent renewable energy, 45percent natural gas, and 4percent fuel oil.[1]

Generally, an electricity mix consists of carbon-based fuels (oil, natural gas, and coal), renewable energy (biomass, hydropower, geothermal, wind, and solar), and nuclear energy. Algonquin-Liberty has facilitated robust initiatives toward expanding renewable energy compared to regional energy providers. In 2020, Algonquin-Liberty shut down their Asbury coal plant to make room for the construction of a wind power facility, which has contributed significantly to the reduction of Algonquin-Liberty's use of carbon-based fuels. They aim to reach 75percent renewable energy by 2023. This transition towards a low-carbon economy is important in facilitating a diverse mix of regional power sources. Figure 2-1 illustrates their resource mix composition by their generation capacity and their actual generation by resource.

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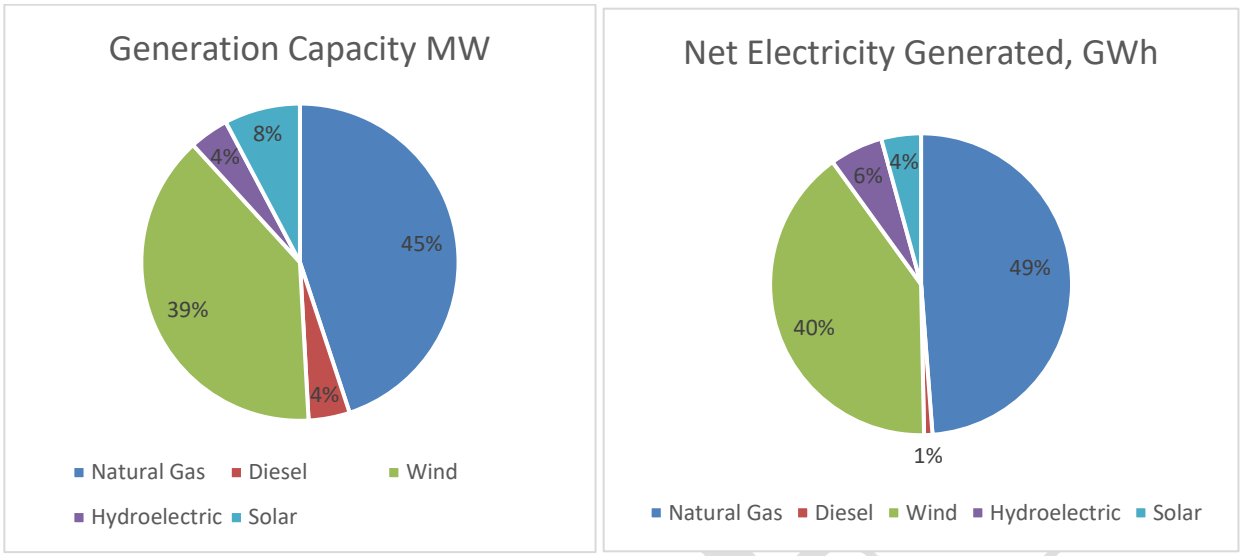
[1]Algonquin-Liberty. 2021. "2021 ESG Report." Available online: https://algonquinpower.com/uploads/docs/AQN-ESG-Report-2021.pdf

Figure 2-1: Algonquin-Liberty 2020 Resource Mix by Capacity and Generation



2.2 Natural Gas Provider: Spire

The City's natural gas is provided by Spire. They do not have data on their resource mix publicly available. Spire has committed to becoming carbon neutral by 2050 through the diversification of their resource mix, which includes implementation of renewable natural gas (RNG) and natural gas blended with hydrogen. During the 2022 Fiscal Year, Spire indicated they will work with Missouri State legislators to further finalize regulations allowing the corporation to embed RNG into their current provider structure, making this source much more accessible to customers.[2]

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[2] Spire Energy. 2021. "2021 Sustainability Report." Available online: https://spireenergy.com/sites/default/files/2022-06/Spire-FY21percent20Sustainabilitypercent20Report.pdf

3.0 MUNICIPAL FACILITIES ENERGY CONSUMPTION

The City maintains 35 municipal facilities with a combined area of over 500,000 square feet[3]. This study evaluates the energy consumption for 13 representative City-selected facilities which comprise just under 250,000 square feet and include government buildings, fire stations, and airport facilities. This section includes an overview of the facilities energy consumption, an evaluation of the data, and recommendations for energy efficiency and diversification.

3.1 Methodology

Data for this evaluation was provided by the City between January 2021 and December 2021 at 13 City-selected facilities. Data was provided in an Excel format tracking sheet. No utility bills were provided; therefore, this data was not independently verified by Burns & McDonnell. Electricity data was provided in kilowatt hours (kWh), and natural gas data was provided in hundreds of cubic feet (CCF). Not all facilities had associated natural gas data, but all had electricity data. All units were converted to a single unit of measurement, kBtu, using U.S. Environmental Protection Agency (U.S. EPA) Energy Star conversion factors to be able to evaluate the two power sources together identified in Table 3.1[4]. A detailed summary of each of the evaluated facilities and their consumption is provided in Appendix A.

Table 3-1: Energy Star Conversion Factors

Electricity	1 kWh = 3.412 kBtu
Natural Gas	1 CCF = 102.6 kBtu

Burns & McDonnell only received cost information for electricity usage and not for natural gas; therefore, a financial evaluation has not been conducted. Any on-site electrical generation or fuel consumption such as the use of generators was not provided, therefore, are excluded from consideration for this evaluation.

3.2 Facilities Energy Consumption

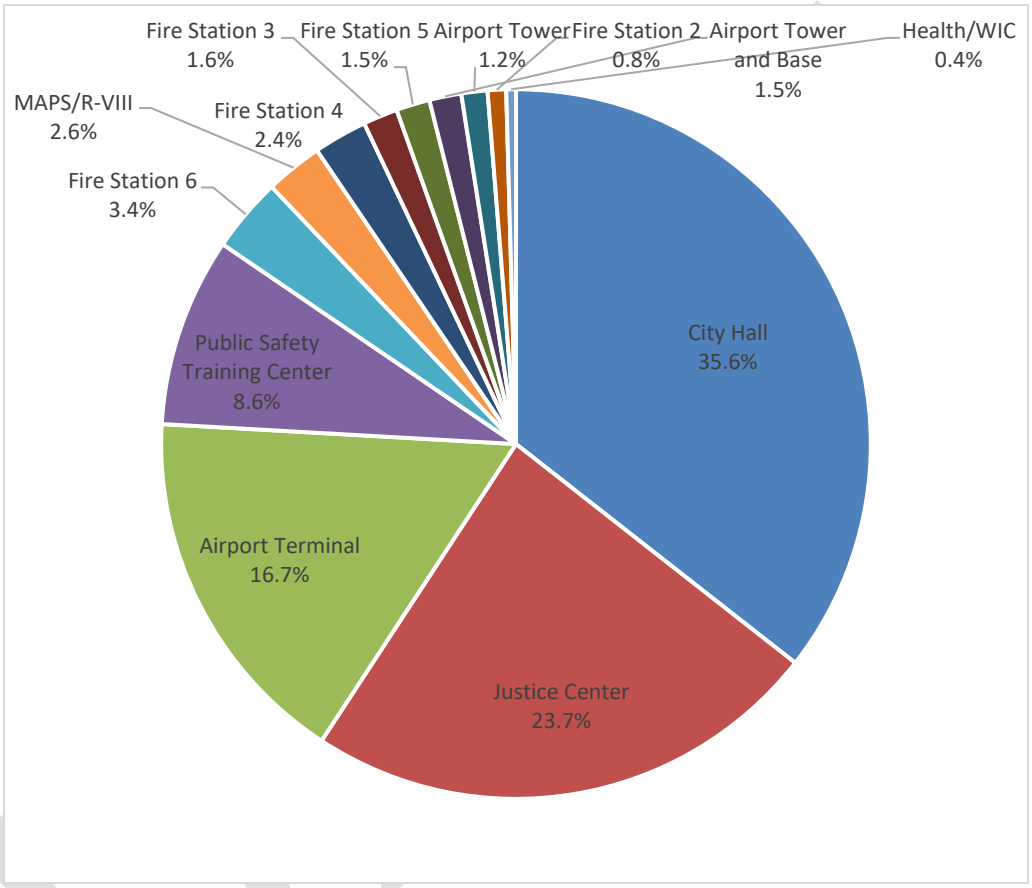
In 2021, City representative facilities consumed approximately 10.2 million kBtu of electricity and 12.2 million kBtu of natural gas for a total of over 22.4 million kBtu. Just four of the 13 facilities comprised nearly 85 percent of the total consumption. The four most significant energy consumers were City Hall (36percent), the Justice Center (24percent), the Airport Terminal (17percent) and the Public Safety

[3] Joplin, Missouri website. http://www.joplinmo.org/910/Facility-Maintenance Accessed October 18, 2022.
[4] Energy Star. August 2015. "Thermal Energy Conversions." Available online: https://portfoliomanager.energystar.gov/pdf/reference/Thermalpercent20Conversions.pdf

Training Center (9 percent). Various factors are attributed to energy consumption at each facility including operating hours, occupancy use, foot traffic, age, and size.

Figure 3-1 compares the combined electricity and natural gas energy consumption for each of the City's representative facilities.

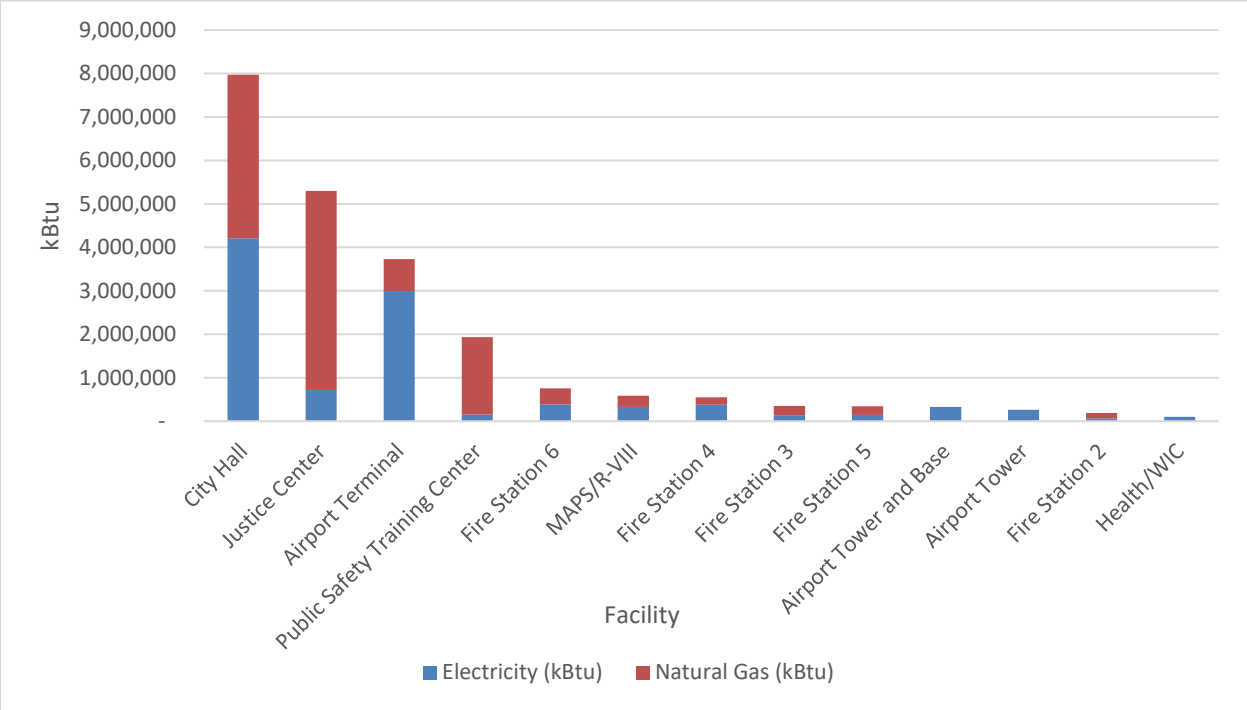
Figure 3-1: Combined Electricity and Natural Gas Energy Consumption for Facilities in 2021 (kBtu)



Within the four highest consuming facilities, the ratio of electricity to natural gas varied significantly. City Hall's natural gas made up 47 percent of the facility's total energy consumption, which powers only heating, ventilation and air conditioning (HVAC) hydronic heating boilers. The Justice Center's total energy consumption consisted of 86 percent natural gas, which powers a domestic hot water system, HVAC hydronic heating boilers, and a cooking stove. The Airport Terminal's natural gas consumption comprised 20 percent of the facility's total energy consumption, which powers a domestic hot water system and HVAC hydronic heating boilers. The Public Safety Training Center had the highest proportion of natural gas consumption out of its total energy consumption at 92 percent natural gas, which powers a domestic hot water system and HVAC hydronic heating boilers. Both the Justice Center and the

Public Safety Training Center should be further evaluated to understand the source of the high natural gas consumption. There was no natural gas data provided for the Airport Tower and Base, the Airport Tower, or the Health/Women, Infant and Children (WIC) facilities. It is assumed that no natural gas is supplied to those facilities. Figure 3-2 presents a breakdown of the electricity and natural gas consumption by City facilities.

Figure 3-2: Electricity and Natural Gas Energy Consumption by Municipal Facilities in 2021



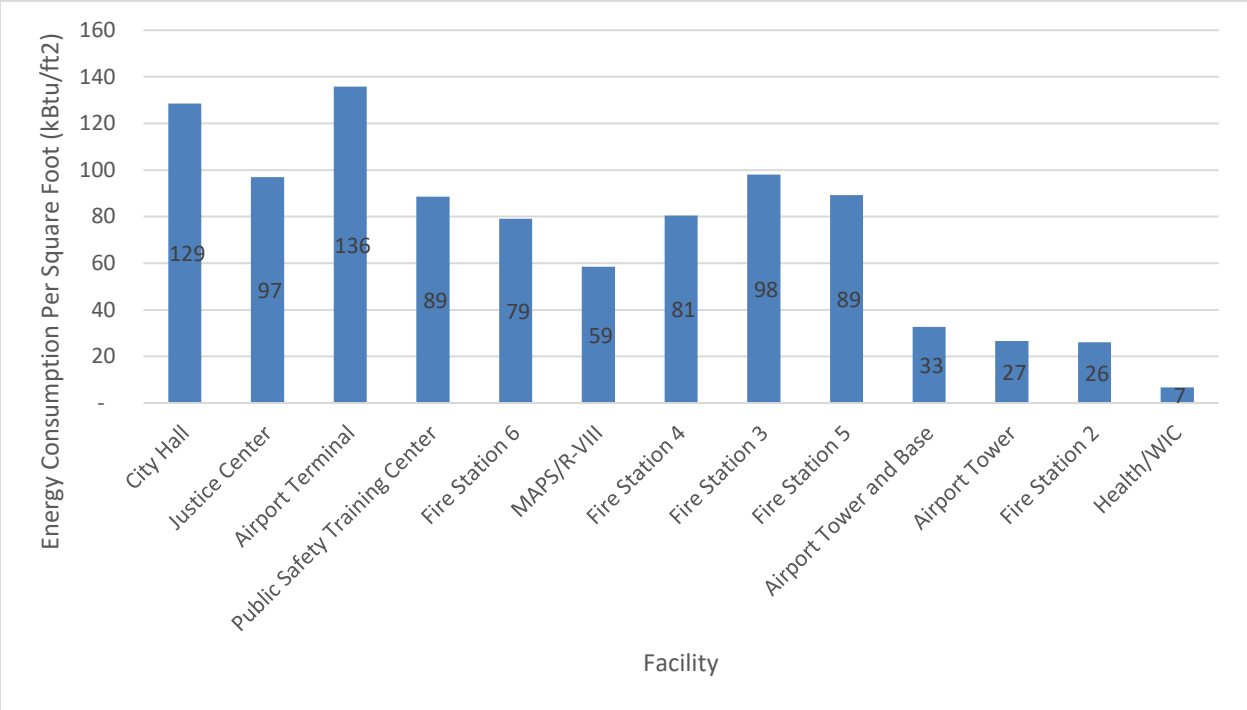
3.3 Facilities Energy Use Intensity

The Energy Use Intensity (EUI) expresses a building's energy use as a function of its size in terms of consumed energy per square foot. This method considers whether a certain amount of energy that is being consumed is high or low relative to its size, which assists in identifying opportunities for energy efficiency improvements. Facility EUI is important in benchmarking operational performance, and it is best utilized when evaluating against similar facilities and functions. A relatively high EUI illustrates that a building may have poor energy performance, while a lower EUI presents efficient energy performance. This metric takes into account both electricity and natural gas consumption, however, it does not account for other factors that may impact usage such as number of employees, operating hours, or heating and cooling days.

The 13 facilities highlighted for this evaluation make up 241,731 square feet. City Hall and the Airport Terminal have the poorest performing EUI at 129 and 136 respectively. Figure 3-3 illustrates the EUI for

City facilities in 2021. The figure places each facility in the same order as Figure 3-2, which maintains consistency and allows benchmarking to occur.

Figure 3-3: Energy Use Intensity for Municipal Facilities in 2021



3.3.1 Energy Star Benchmarking

The U.S. EPA Energy Star program provides research on data trends comparing hundreds of thousands of buildings energy use by specific sectors. The most relevant sector to the City's facilities evaluated fall into the "Office Use" category. The Energy Star DataTrends report from January 2015 sited a typical office building median EUI of 184 kBtu per square foot with a range from less than 100 to more than 1,000.[5] All of the City's facilities evaluated fall under the median Energy Star EUI.

3.4 Facilities Evaluation

City Hall. City Hall has the most square footage of all the evaluated City facilities with 62,000 square feet. It is therefore, understandably, the highest consumer of energy. The EUI score of 129 kBtu per square foot identifies City Hall as a lower performing facility compared to the other City facilities evaluated, potentially due to the age of the facility, and it should be a priority for improvements in energy efficiency.

[5] Energy Star Data Trends Report. "Energy Use in Offices" 2015.
https://www.energystar.gov/sites/default/files/tools/DataTrends_Office_20150129.pdf

Justice Center. The Justice Center has the second largest square footage with 54,670 square feet and is the second highest consumer of energy. The Justice Center has an EUI of 97 kBtu per square foot which is a better score than City Hall, however as the City's second-highest energy-consuming facility, it should also be a priority for energy efficiency improvements. Also, with 86percent of its energy use from natural gas it is recommended that further evaluation be conducted to understand what may be the cause. Potential areas for consideration include the building's HVAC equipment and insulation, as the age of equipment often indicates performance and poor insulation allows heat to escape the building easily.

Airport Terminal. The Airport Terminal is the third largest facility evaluated with an area of 27,500 square feet and the third highest consumer of energy. The Airport Terminal had the highest EUI in the City at 136 kBtu per square foot with 80 percent of its energy use from electricity and 20 percent from natural gas. The EUI of this facility is expected to be relatively high due to a greater population density. It has a daily building occupancy of up to 200 people per day in 27,500 square feet of area, or one person occupying every 138 square feet of area. The facility size and energy consumption highlight this facility as an opportunity for energy efficiency improvements.

Public Safety Training Center. The Public Safety Training Center is the fourth largest facility evaluated with an area of 21,800 square feet and the fourth highest consumer of energy. It has an EUI of 89 kBtu per square foot. This facility has a high ratio of natural gas at 92percent of the buildings total energy consumption, potentially due to aged HVAC equipment. Further evaluation should be conducted to determine opportunities to decrease usage.

Fire Stations. Five fire stations were included in this study and while the fire stations are lower energy consumers of all the facilities evaluated, they present a unique opportunity for comparison. The size of the fire stations range from 3,600 to 9,600 square feet. All fire stations are assumed to perform the same services across the City and have the same number of employees, however, Fire Stations 3, 4, 5, and 6 each had annual consumptions two to four times as much as that of Fire Station 2. Fire Station 2 had an EUI of 26 kBtu per square foot which was significantly more efficient than the four other fire stations, ranging from 79 to 98 kBtu per square foot. The City should further evaluate the energy systems of Fire Station 2 to understand areas where performance is high compared to the other fire stations.

3.5 Key Findings and Opportunities

The overall performance of the City's evaluated facilities appears to be appropriate for the building size and occupancy as benchmarked against one another. The performance is above average compared to the Energy Star benchmark communities. Opportunities exist throughout the City for improving efficiency.

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The City should prioritize the four highest energy consuming buildings for further evaluation, upgrades, and retrofits including City Hall, the Justice Center, the Airport Terminal, and the Public Safety and Training Center. Fire Stations 3, 4, 5, and 6 are opportunity areas for evaluation especially for comparison to Fire Station 2 which is outperforming all other stations. Specific recommendations and opportunities are as follows:

1. **Tracking and reporting.** To fully understand the City's facility energy performance, it is recommended that the City monitor total energy consumption in a strategic method that collects data in a centralized location. Energy Star has a free, widely utilized tool called Portfolio Manager that helps numerous local governments and organizations monitor their energy systems as well as air emissions, and financial analyses. Portfolio Manager can be used to benchmark the City's facilities against other buildings of similar size and function to understand and create a baseline for energy consumption. This tool also considers the following factors in addition to the electricity and natural gas usage: mobile equipment, HVAC systems, lighting, onsite diesel generators, emergency generators, fire pumps, and records of refrigerant charge per unit. This information is necessary to fully evaluate the City's energy usage while also understanding the full scope of each process that consumes energy beyond the data provided.
2. **Retrofits and upgrades.** The City should prioritize facilities in need of retrofitting before identifying areas that would benefit from investments in renewable energy. Retrofitting is one of the most cost-effective means of improving energy efficiency in buildings.[6] Retrofits may consist of lighting upgrades, leakage reductions, and HVAC system upgrades.
3. **Onsite renewable energy.** The City should evaluate opportunities to install solar photovoltaic panels for onsite power generation, which would reduce the use of carbon-based fuels and improve energy efficiency. This can be facilitated through the development of a solar deployment plan, which sets objectives for projected energy consumption, and evaluates financial opportunities. The City should conduct a site-specific climate, space, and weight study to fully understand opportunities for the most significant solar power generation while also assessing the investment return on solar panels.
4. **Solar power farm.** The City may consider a large-scale solar power farm for supplying energy for numerous facilities. While onsite solar power generation provides value, some facility rooftops may lack adequate space or weight capacity to add rooftop solar panels. Locations such as the Airport may have the acreage required to support such a project. Many other Cities have

[6] Energy Star. 2007. "Building Manual." Accessed August 5, 2022. https://www.energystar.gov/sites/default/files/buildings/tools/EPA_BUM_CH5_RetroComm.pdf

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been successful at siting solar farms at airports including Denver International Airport, Indianapolis International Airport, and Sacramento International Airport.

5. **Solar power purchase agreements.** The City can also make use of solar power purchase agreements, which are financial agreements by third-party solar panel developers that would allow the city to purchase energy from the owners of the solar panels rather than purchasing the systems themselves. This option would allow for off-site solar power to be distributed to the City, much like how energy is delivered to the City by Algonquin-Liberty and Spire. This option would be implemented as a complement to or as an alternative to onsite solar power generation in the City.
6. **Build efficiently.** As the City looks to develop new projects, it should utilize management frameworks and tools such as Envision™, which provides a rating system for evaluating a project's sustainability impact. Local government planners, scientists, and engineers can utilize this framework to improve the resiliency of civil infrastructure while incentivizing performance goals beyond minimum requirements.

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4.0 FLEET FUEL CONSUMPTION

The City's fleet inventory was evaluated to identify opportunities for improvements in fuel efficiency while also identifying opportunities for vehicle electrification. The City's fleet consists of 258 vehicles across 23 department categories. This section contains an overview of the City's fleet fuel consumption, an evaluation of the data, and recommendations for a more efficient and diversified fleet.

4.1 Methodology

Data used in this evaluation was provided by the City for the fiscal year (FY) 2021 and included data for 258 fleet vehicles. The inventory data included the vehicle description, municipal department or category, tag identification, gallons of fuel consumed, mileage, and miles per gallon (MPG). Fleet data was provided in gallons of fuel and did not define whether a vehicle utilized gasoline or diesel; for this evaluation, it was assumed that the entirety of the City's fleet inventory uses gasoline. A table of each of the evaluated fleet departments, their vehicle count, and their vehicle type is found in Appendix B. Each vehicle was classified into one of eight vehicle types: pickup truck, passenger car, heavy equipment machine, light commercial vehicle, passenger SUV, transit bus, firetruck, and motorcycle.

4.2 Fuel Consumption

The 258 fleet vehicles included in this evaluation consumed 182,334 gallons of fuel in FY 2021. The Police Department operated 60 of these vehicles, having the largest fleet in the City. The Streets Department followed closely with the second largest fleet of 56 vehicles. The Fire Department had 17 vehicles. Each of the remaining 20 City departments had fewer than 17 vehicles. Table 4-1 displays the City's fleet operations by department and includes the vehicle count, average vehicle age, total mileage, fuel consumed, and the average MPG.

Table 4-1: Fleet Data by Department – FY 2021

Department	Number of Vehicles in Use	Average Age	Total Miles	Total Gallons of Fuel	Average MPG
Police	60	6	639,890	55,657	11
Streets	56	10	111,107	30,514	3
Fire Department	17	12	65,802	12,728	8
Wastewater	16	10	78,779	8,249	9
Airport	15	12	23,971	4,939	4
Public Grounds	14	9	69,663	6,683	10
MAPS	13	4	229,661	38,159	6
Parks	11	13	5,174	2,684	7

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Cemetery	8	11	16,329	2,791	5
Engineering Division	8	14	28,847	2,228	13
Health	8	8	48,630	3,919	17
Sewer	6	11	30,608	3,108	6
Sign Shop	6	9	17,945	2,229	6
Sports Complex	4	7	11,044	1,461	10
Building Maintenance	3	13	13,202	1,142	11
Code Enforcement	3	13	10,099	782	12
Golf	2	12	7,683	786	10
Investigations	2	7	13,204	879	15
Recycling	2	13	2,249	181	9
Center for Visitors Bureau	1	3	940	60	16
Council	1	8	1,363	66	21
Emergency Response Operations	1	4	32,178	2,534	13
Ground Maintenance	1	2	4,955	557	9
Total/Average	**258**	**9.2**	**1,463,324**	**182,334**	**10**

The Police Department was the City's highest vehicle fuel-consuming group at 31 percent of the fleet's total fuel consumption. The Metro Area Public Transit System (MAPS) consumed 21 percent of the fleet's total fuel, the second highest-consuming group in the City. While MAPS was a significant consumer, public transportation is assumed to be offsetting single-passenger vehicles. The Streets Department consumed 17 percent of the fleet's total fuel, making it the third highest-consuming group in the City. Figure 1-6 illustrates the City's fleet fuel consumption in FY 2021.

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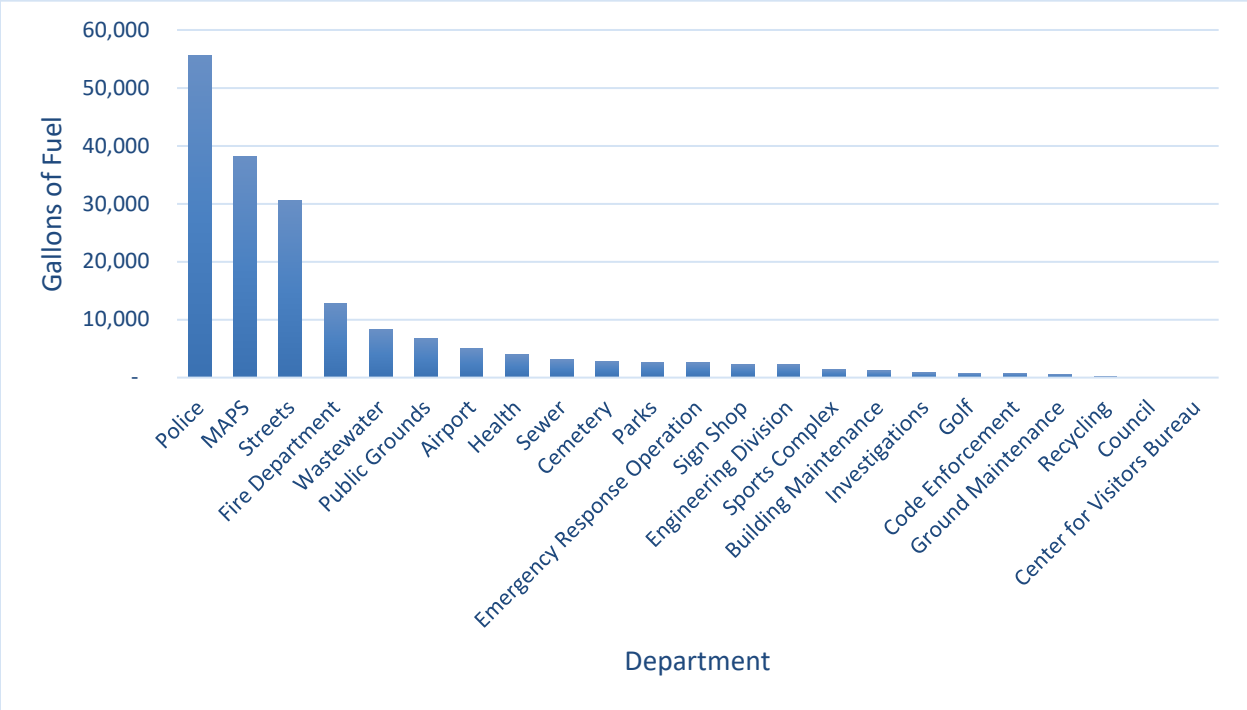
Figure 4-1: Total Fuel Consumed Per Department in FY 2021

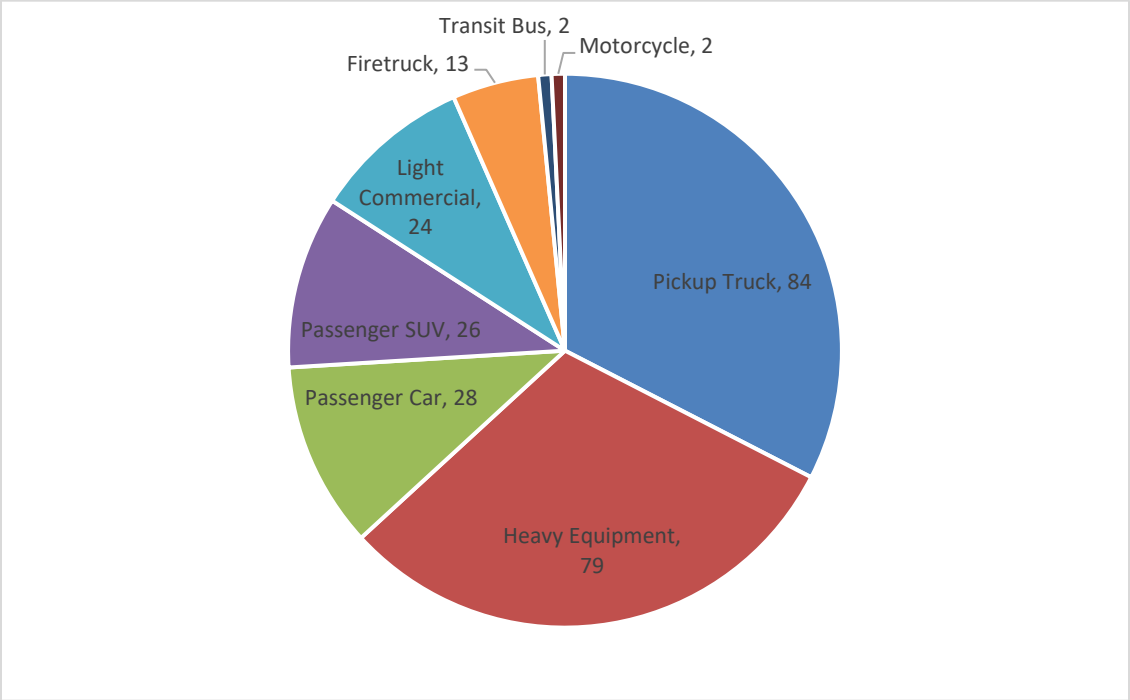


4.3 Fleet Operations Evaluation

The City's fleet inventory consists of vehicles with diverse functions, so each department's vehicle composition was evaluated to identify areas needing improved fuel performance. A passenger car and sport utility vehicle (SUV) will generally consume less fuel per mile traveled than a transit bus or firetruck, which uses greater amounts of fuel because of their varying size, function, passenger count and cargo, and age.

The Police Department had the most diverse range of vehicle types, of which 37 percent were passenger SUVs and 38 percent were passenger cars. The Streets Department utilized 82 percent of the City's heavy equipment machines. The City's FY 2021 fleet inventory consisted of the following vehicle types and their respective proportion of the total fleet size: 33 percent pickup trucks, 31 percent heavy equipment machines, 11 percent passenger cars, 10 percent passenger SUVs, 9 percent light commercial vehicles, five percent firetrucks, less than 1percent motorcycles, and less than one percent transit buses. Figure 4-2 breaks down the City's fleet by vehicle count and type.

Figure 4-2: Vehicle Count by Type



Age is an important factor when considering opportunities for improved fuel efficiency and alternative fuel sources. This data will help the City understand the cost-effectiveness of fleet electrification or viable options for retrofits and upgrades. Newer vehicles of the same type will generally be more fuel efficient, while older vehicles will be less efficient. However, the City should evaluate each vehicle type and its corresponding age to identify areas for improvement. Some vehicle types require extensive duties, and some types perform more fuel-intensive tasks compared to others.

The average City vehicle age is 9.2 years. Firetrucks and transit buses are the oldest with an average age of 10 years for each vehicle. The City's motorcycle fleet is the newest, with an average age of 4 years. The City's passenger car and SUV fleets have an average age of 6 years for each vehicle while also having much more significant quantities of vehicles. Because these two vehicle types have high quantities in the fleet inventory, they should be of greater priority for the City to further evaluate opportunities for fuel efficiency. Figure 4-3 displays the average age for each vehicle type for the City's fleet.

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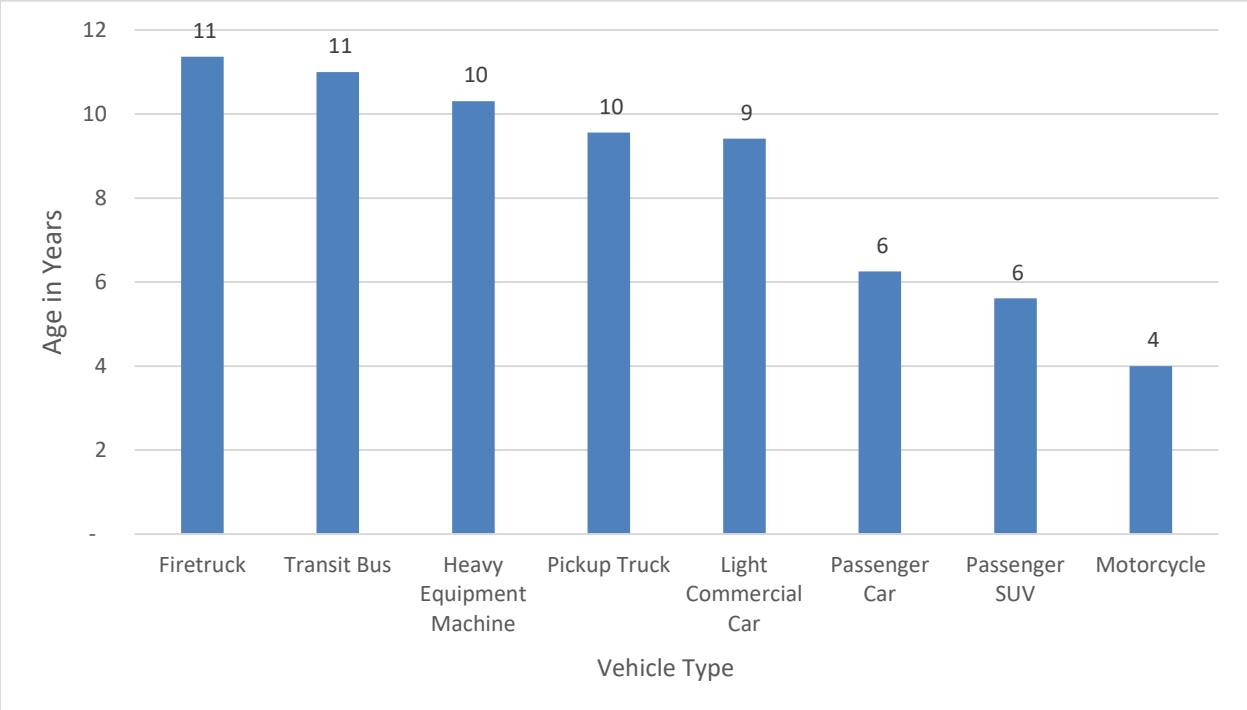
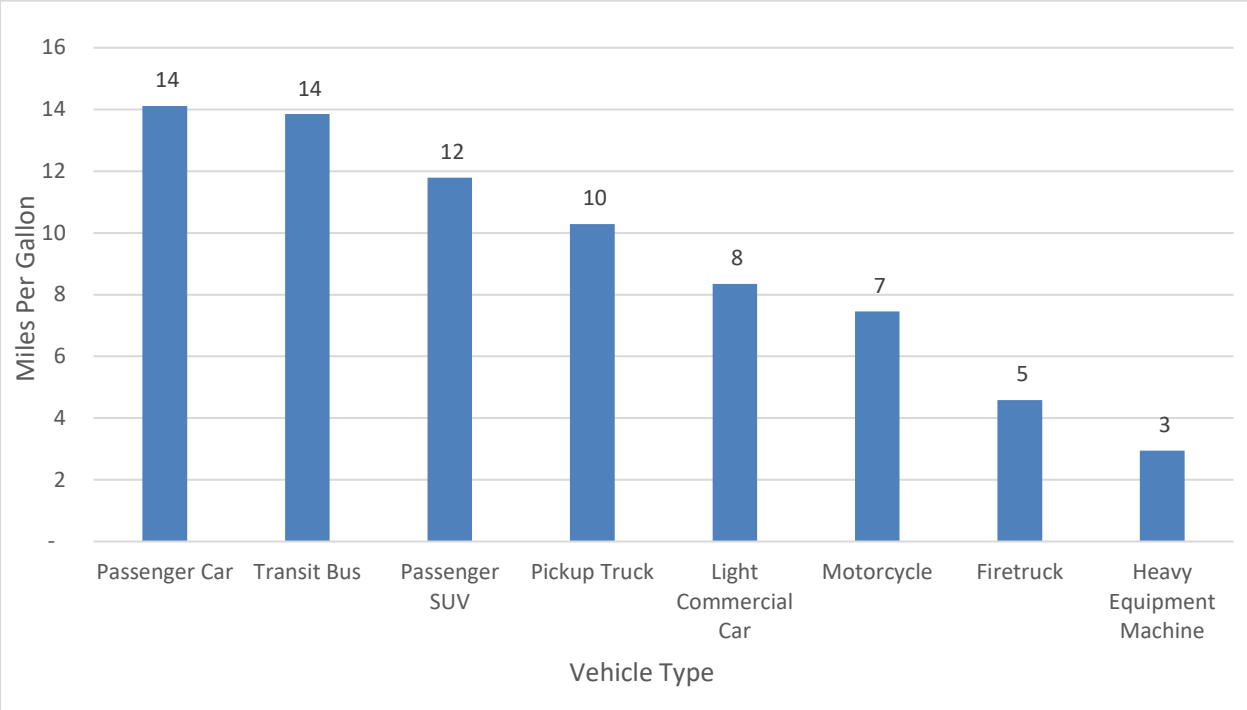
Figure 4-3: Average Age by Vehicle Type



The City's performance for each vehicle type was evaluated using data on MPG, also known as the fuel economy. Fuel economy is important in understanding the attainable mileage for each vehicle. More efficient vehicles will have a higher MPG, while less efficient vehicles will have a lower MPG. Furthermore, many factors may impact the fuel economy, such as size, distance traveled, idling time, average speed and engine/motor load, operating weight, age, and fuel type.

Passenger cars and transit buses had an average of 14 MPG, making them the highest performing vehicle type in the City. Passenger SUVs followed closely with an average of 12 MPG. Pickup trucks followed suit in a similar range with an average of 10 MPG. On the other hand, the City's heavy equipment machines displayed the lowest performance with an average of 3 MPG, which can be attributed to those vehicles performing tasks that require significantly less traveling or may be operated only on-site at a facility. The City should further evaluate the fuel economy of each of these vehicle types while also considering low-performing vehicles such as heavy equipment machines and firetrucks, which may not be as suitable for electrification because of a lack of options in the market. Figure 1-9 illustrates the average MPG for each vehicle type.

Figure 1-9: Average Miles Per Gallon By Vehicle Type



The police department's large quantity of passenger cars and SUVs should be evaluated for electrification while also considering the vehicle's function for emergency services in the City. The passenger cars used by the Police Department are the Chevy Impala, Dodge Charger, and Ford Taurus. The passenger SUV models used by the police department are the Chevy Tahoe and Ford Explorer. These vehicles offer relatively high performance for law enforcement activities, they are newer compared to the rest of the fleet, and they consume the largest quantity of fuel when compared to other vehicle categories. The City would find value in applying fuel efficiency improvements to these vehicles and seeking to electrify some passenger vehicles operated by the Police Department.

The City utilized 84 pickup trucks, representing 33 percent of the fleet inventory. This vehicle type had an average of 10 MPG and an average age of 10 years. The City should further evaluate the function of each of these trucks, especially when considering whether a vehicle corresponds to its task, also known as vehicle rightsizing. The wastewater, public grounds, engineering, sign shop, sports complex, code enforcement, golf, and investigations departments rely on the use of pickup trucks. These vehicles should be a high priority for the City to further evaluate opportunities for rightsizing, hybrid vehicle options or electrification.

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4.4 Key Findings and Opportunities

The City's fleet serves as a vital role in delivering services to the community. There are several opportunities for the City to consider implementing with a range of associated investments of time and resources. The City should prioritize low-performing vehicles for the planning and implementation of the proposed recommendations: pickup trucks, passenger cars, and light commercial vehicles. The following options are recommended to reduce overall fuel consumption in fleet operations.

1. **Anti-idling policy**. Anti-idling policies for all fleet vehicles can help mitigate operational fuel consumption and costs by reducing the time that vehicles are powered on and not conducting city services. Idling in vehicles leads to wasted fuel, decreases effective miles per gallon (idling has 0 MPG), generates significant air pollution, and increases wear on mechanical parts and the battery. These policies can be facilitated through employment contracts, facility signage, and frequent team reminders for vehicle operators. In addition to practicing idling-prevention when parked, many modern fossil-fueled vehicles can be purchased with automatic engine start-stop to further reduce engine idling when temporarily stopped in traffic or at intersections.

2. **Proactive maintenance**. Proactive maintenance schedules are also key to maintaining vehicle health while also optimizing the fuel performance of fleet vehicles. Measures such as regular engine tune-ups, proper tire air pressure, balance, and rotation, and regular engine oil changes (with the correct grade of oil) can all ensure high efficiency for fuel-powered vehicles without implementing retrofits or introducing electric vehicles. Removing unnecessary weight from a vehicle is another simple behavioral practice to save fuel, improving fuel economy by up to two percent for every 100 pounds of cargo removed.[7]

3. **Route optimization.** Route optimization through telematics can provide insights on efficient routes for vehicle operators and can evaluate driver behaviors that may impact the fuel efficiency of a vehicle. Telematics can detect aggressive starts and stops, unnecessary shifting, and excessive idling. City fleet managers can use this information and relay it to vehicle operators to facilitate best practices for fuel efficiency throughout fleet operations. As much as practical, department vehicles should limit or avoid operation during rush-hour traffic hours; heavy traffic increases vehicle accelerating, braking, and idling time. Additionally, it is more efficient to

[7] US Department of Energy. 2012. "Vehicle Technologies Program." Available online: https://afdc.energy.gov/files/u/publication/10_G00888_savings_WEB.pdf

combine multiple trips into a single planned route, driving to the furthest destination first so that the engine is running at its ideal operating temperature for as much of the drive as possible.

4. **Vehicle rightsizing.** The City can evaluate their fleet for vehicle rightsizing, ensuring that the vehicle's size corresponds to the driver's designated task. Some considerations for the city include the type of tasks that may require large trucks or can be carried out in smaller vehicles that offer better fuel efficiency. The City should further evaluate their pickup trucks to identify whether these vehicles correspond to the proper tasks of its department's function.

5. **Fleet Electrification.** The City should further evaluate the following vehicle types to identify opportunities to purchase electric vehicles (EVs) or hybrid-electric vehicles (HEVs): passenger cars, passenger SUVs and pickup trucks. By switching to EV or HEV, the City would face significantly lower mileage per gallon and support a transition to a low-carbon economy. These vehicle types will have a wide range of market options compared to special-use or large vehicles that may not have electric options available. The City would greatly benefit from the electrification of their passenger cars and pickup trucks, especially for vehicles that are aging and that exhibit a lower MPG among the rest of the fleet. Options such as EVs and HEVs offer opportunities for economic benefits while also reducing the quantity of air emissions from vehicles. The City would face lower fuel costs for EVs compared to fuel-powered vehicles, however, may face higher purchasing costs without taking maintenance costs into consideration. Costs can be offset by utilizing programs such as the federal Qualified Plug-In Electric-Drive Motor Vehicle Tax Credit. Fuel efficiency from EVs is considerable, and in some instances, EVs can exceed the equivalent of 130 miles per gallon while only consuming up to 40 kWh in the span of 100 miles. Life expectancies for EVs are also high, in which the average EV battery can last up to 15 years.[8] As discussed earlier in the report on City facilities, the installation of onsite EV charging stations can complement the implementation of solar power generation in the City.

   Furthermore, the City would face far more economic benefits by utilizing EVs in their fleet operations and would see the most significant impacts from the electrification of vehicles with the highest annual fuel consumption. Most EVs have a fuel economy ranging from 50 to 140 MPG and the typical fuel consumption of an electric vehicle is about 25percent or less than that of a gasoline-powered vehicle. One of the City's highest fuel-consuming vehicles, a 2016 Dodge Ram 2500 (Pickup Truck in the Streets Department), consumed 1,504 gallons of gasoline (209,056

[8] US Department of Energy, "Alternative Fuels Data Center." Available online: https://afdc.energy.gov/fuels/electricity.html

kBtu) and utilized 15,177 miles in 2021 with a fuel economy of 10 MPG. Assuming a 75percent decrease in fuel consumption for an electric vehicle of equivalent size, weight, and function, it would only consume about 52,264 kBtu or 15,318 kWh.[9] Based on the City's average cost of electricity in 2021, the City would pay $1,225 for an electric vehicle with the same utilization as the 2016 Dodge Ram 2500, amounting to nearly 29percent the total cost of gasoline for this vehicle.[10]

6. **Compressed natural gas.** The City may further evaluate the option of converting some applicable fleet vehicles to compressed natural gas (CNG). There is potential to utilize RNG generated at the City's WWTPs as biofuel (see Section 5.4). Additional evaluation is required to determine which vehicles could be converted to CNG or replaced with new CNG vehicles while still meeting needs. Conversion of vehicles to CNG reduces fossil fuel consumption, but to reduce cost, a financial feasibility study is prudent to determine the capital, operational, and maintenance costs versus traditional vehicles as well as the fuel cost savings. Often, municipalities plan a phased approach to the conversion of vehicles to CNG on a replacement schedule.

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[9] The typical energy consumption of an electric vehicle is about 25percent less than that of a combustion engine vehicle.
[10] Regular unleaded gasoline prices for the Midwest in 2021 averaged $2.856 per gallon. https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r20_a.htm

5.0 WWTP ENERGY USAGE

Water treatment facilities are often the most energy intensive operation within a municipality. The City of Joplin operates two wastewater treatment plants, Shoal Creek WWTP and Turkey Creek WWTP, that are treating an average daily flow of 6.5 million gallons per day (MGD) and 15 MGD, respectively. This section reviews the energy consumption from these two operations based on utility data and provides recommendations for improvements for efficiency.

5.1 Methodology

Utility data was provided for electrical and natural gas usage related to WWTP operations in 2021. Each WWTP's energy usage was measured by multiple meters and that information was compiled to provide a picture of how much energy each facility was consuming. All the energy units were converted to kBtu as a baseline comparison unit. Information about equipment usage at specific facilities was not provided for this evaluation. Incomplete partial energy usage data was provided for Filmore Bridge Lift Station, so it was not included in analysis, resulting in an incomplete depiction of the overall energy consumption of WWTP operations. Natural gas consumption was provided for Turkey Creek and Shoal Creek, but no natural gas consumption was provided for the Tin Cup Lift Station, so it was assumed to exclusively consume electricity.

5.2 WWTP Energy Usage

Turkey Creek WWTP consumed approximately equal amounts of electricity and natural gas at 23.5 million kBtu and 24.2 million kBtu respectively. Shoal Creek WWTP consumed a much higher ratio of electricity to natural gas at approximately14.3 million kBtu and 3.8 kBtu respectively. Tin Cup consumed approximately 2 million kBtu of electricity and no natural gas. Table 5-1 summarizes the total consumption by source and associated cost breakdown by location. Turkey Creek WWTP consumes the most energy likely due to its larger size and capacity compared to Shoal Creek WWTP. Figure 5-1 compares each facilities energy consumption by electrical and natural gas usage in kBtu.

Table 5-1: Annual WWTP Energy Consumption

Facility	Electricity (kBtu)	Natural Gas (kBtu)	Cost	Unit Cost ($/kBTU)
Turkey Creek WWTP	23,470,976	24,213,261	$769,262	0.016
Shoal Creek WWTP	14,290,368	3,776,911	$365,968	0.020
Tin Cup	2,035,240	NA	$58,769	0.029

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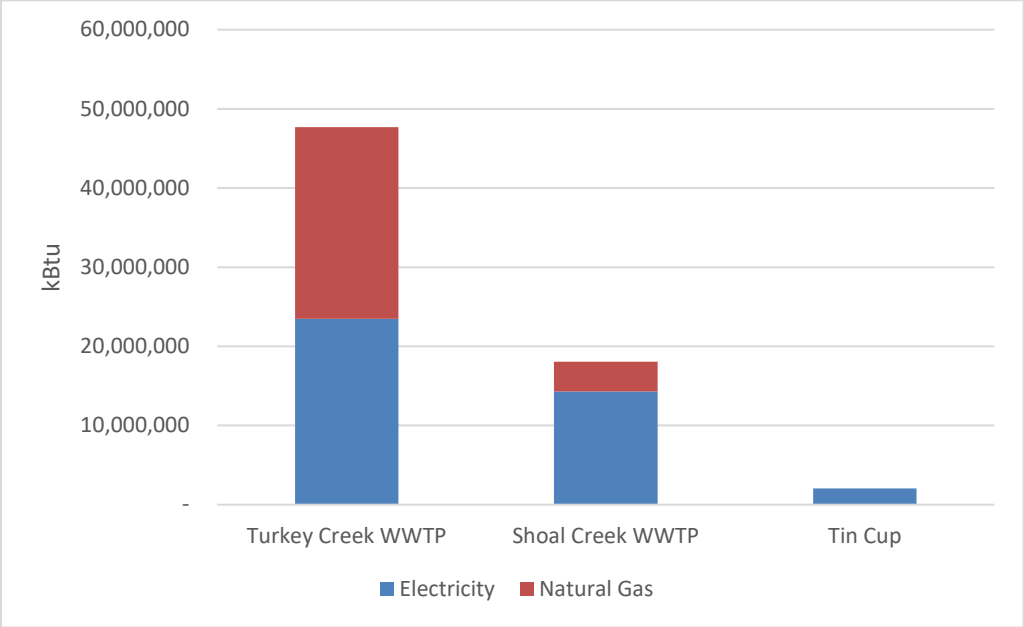
Figure 5-1: 2021 WWTP Energy Consumption



5.3 WWTP Evaluation

The EUI of a WWTP expresses a plant's energy use as a function of its size in terms of consumed energy per MGD. This method considers whether a certain amount of energy that is being consumed is high or low relative to its size, which assists in identifying opportunities for energy efficiency improvements. The EIU of the Turkey Creek WWTP is approximately 8,700 kBtu/MGD and the Shoal Creek WWTP is approximately 7,600 kBtu/MGD. The Shoal Creek WWTP appears to be operating more efficiently compared to the Turkey Creek WWTP based on the utility data provided. However, differences in treatment technologies, age of equipment, and actual flow treated can all impact this metric significantly. While the U.S. EPA Energy Star program has collected data on thousands of WWTP across the country, there is not a reliable comparison to benchmark the efficiency of a plant facility wide. This is due to the wide diversity of plant operations and other factors. To understand the efficiencies of the City's operations, a more in-depth study would be necessary of each treatment process within the plants starting with the aeration system and pumping system, which typically constitute the largest energy consumers in a treatment facility.

5.4 Anaerobic Digestion and Renewable Gas

Both Turkey Creek and Shoal Creek WWTP operate anaerobic digestors. The methane generated through this process is captured and flared. Meters were in place at each plant to track the gas generation, however, due to the corrosivity of the gas, the meters have stopped working and there are no reportable

quantities. To effectively evaluate the opportunities for the beneficial use of biogas, it is recommended to reinstall meters, track data, and test gas samples and identify its quality. This valuable data would inform the City in evaluating a suite of potential beneficial use options such as the generation of onsite power and/or heat generation, use as compressed natural gas for future City fleet vehicles, or upgrading the biogas to pipeline quality, where it can be sold into the market while also generating revenue from the sale of renewable fuel credits.

5.5 Key Findings and Opportunities

The analysis for this evaluation included a high-level review of WWTP operations for the City. Any improvements that decrease energy consumption at the facilities would decrease the operating costs of the facilities. Implementing cost-saving and emission reducing measures will help put the City in a position to improve energy security, extend the life of facilities and equipment, and demonstrate leadership in the region. The following options are general recommendations about optimization of the facilities.

1. **Variable-frequency and eddy-current drives**. Equipment such as pumps and blowers are used in numerous wastewater treatment processes and often make up a large part of a WWTP's energy consumption. In many cases, the pumping and air demand can be variable over time, providing an opportunity to consume less power through the incorporation of variable speed controls on the motors. Both variable-frequency drives (VFDs) and eddy-current drives (ECDs) can be installed on existing equipment with electric motors to improve energy efficiency. Instead of equipment being either operating at full power or not operating at all, a VFD or ECD allows for the energy usage to be shifted with changing conditions. For example, when flow is lower than peak times in the detention basin, variable speed control would allow for a pump to operate at 50 percent power instead of having to be toggled between on or off. VFDs are most appropriate for small and medium-horsepower motors and require a more sophisticated maintenance personnel, while ECDs are simpler from a maintenance standpoint but are more suited for larger horsepower motors and medium voltage applications.

2. **Equipment efficiency upgrades.** Examination of older, often more energy consuming, equipment can help identify where either retrofitting or replacement is more appropriate. It is usually more cost-effective to modify existing equipment due to the lack of capital investments; however, equipment that was energy efficient 30 years ago, may be easily replaced with modern technology that uses components such as high efficiency motors. There are also several forms of testing, such as vibration testing, that help identify which equipment needs preventative maintenance, which can help extend the useful life of certain equipment. A comprehensive

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energy-audit of all equipment would provide valuable information about what processes and equipment are the most energy intensive and therefore best suited for optimization.[11]

3. **Peak-use pricing**. Public utilities often have pay structures with electricity providers that include base energy pay structure and peak-use pricing. An in-house energy management training program can be developed to familiarize operators and other staff with these pay structures and contracts to avoid energy-intensive processes during peak-hour periods.[12] In addition, evaluation of larger pumping stations can reveal opportunities to change the pump operation sequence in a manner than reduces the frequency of peak-use pricing without major capital investment.

4. **Upgrade Biogas for Beneficial Use.** Currently the biogas generated from anaerobic digestion at the WWTPs is flared. The City has an opportunity to use this renewable biogas to power facilities and operations at its WWTPs or upgrade the gas for sale to the natural gas pipeline. The City must first determine the biogas flow rate and quality to correctly size equipment to clean and utilize the gas. By utilizing the currently flared biogas, the City could begin to reduce energy consumption at its facilities while decreasing energy costs, carbon footprint, and dependence on non-renewable energy costs, or generating revenue from the sale of renewable fuel credits.

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[11] Energy Efficiency in Water and Wastewater Facilities. Available online: https://www.epa.gov/sites/default/files/2015-08/documents/wastewater-guide.pdf
[12] Wastewater Management Fact Sheet. Available online: https://www.epa.gov/sites/default/files/2019-08/documents/energy_conservation_fact_sheet_p100il6t.pdf

APPENDIX A – ENERGY CONSUMPTION FOR MUNICIPAL FACILITIES

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2021 Energy Consumption for Municipal Facilities

Building Name	Building Area (ft^2)	Electricity Consumption (kWh)	Electricity Consumption (kBtu)	Natural Gas Usage (CCF)	Natural Gas Usage (kBtu)	Total Energy Consumption, Electric + Natural Gas (kBtu)
Airport Terminal	27,500	876,600	2,990,959	7,242	743,029	3,733,988
City Hall	62,000	1,234,000	4,210,408	36,659	3,761,227	7,971,635
Fire Station 4	6,800	111,920	381,871	1,614	165,596	547,467
Fire Station 6	9,600	113,680	387,876	3,622	371,574	759,450
Fire Station 5	3,850	42,668	145,583	1,930	198,018	343,601
Fire Station 3	3,600	39,287	134,047	2,134	218,948	352,996
MAPS/R-VIII	10,000	96,440	329,053	2,498	256,295	585,348
Airport Tower and Base	10,000	95,840	327,006	-	-	327,006
Justice Center	54,670	211,440	721,433	44,624	4,578,469	5,299,902
Fire Station 2	7,200	18,880	64,419	1,205	123,660	188,078
Public Safety Training Center	21,824	45,120	153,949	17,325	1,777,545	1,931,494
Health/WIC	14,687	28,960	98,812	-	-	98,812
Airport Tower	10,000	77,950	265,965	-	-	265,965
Total	**241,731**	**2,992,785**	**10,211,382**	**118,853**	**12,194,361**	**22,405,743**

Note: Blank cells indicate inadequate or unavailable data.

APPENDIX B – FLEET INVENTORY BY DEPARTMENT

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Fiscal Year 2021 Fleet Inventory By Department and Vehicle Type

Department	Pickup Truck	Heavy Equipment Machine	Firetruck	Passenger Car	Light Commercial Vehicle	Passenger SUV	Transit Bus	Motorcycle	Total Vehicles in Use
Police	3		1	23	8	22	1	2	60
STS	10	46							56
Fire Department	4		11		1	1			17
WW	14	2							16
Airport	5	9	1						15
Public Grounds	10	3				1			14
MAPS	2				10		1		13
Parks	1	10							11
Cemetery	4	4							8
Engineering Division	7					1			8
Health	3			4	1				8
Sewer	3	3							6
Sign Shop	4	2							6
Sports Complex	4								4
Building Maintenance	1			1	1				3
Code Enforcement	3								3
Golf	2								2
Investigations	2								2
Recycling	1				1				2
Center for Visitors Bureau					1				1
Council					1				1
ERO						1			1
Ground Maintenance	1								1
Total	**84**	**79**	**13**	**28**	**24**	**26**	**2**	**2**	**258**

Note: Blank cells indicate inadequate or unavailable data.

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