Strategies for Municipal Fleet Electrification

A Fall 2022
Collaborative Project with
Arizona State University's
Project Cities & the
City of Peoria

Sustainable Cities Network
Arizona State University

Project Cities

PART 1:

Project and Community Introduction

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ABOUT ASU PROJECT CITIES

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SUSTAINABLE DEVELOPMENT GOALS

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This report represents original work prepared for the City of Peoria by students participating in courses aligned with Arizona State University's Project Cities program. Findings, information, and recommendations are those of students and are not necessarily of Arizona State University. Student reports are not peer reviewed for statistical or computational accuracy, or comprehensively fact-checked, in the same fashion as academic journal articles. Editor's notes are provided throughout the report to highlight instances where Project Cities staff, ASU faculty, municipal staff, or any other reviewer felt the need to further clarify information or comment on student conclusions. Project partners should use care when using student reports as justification for future actions. Text and images contained in this report may not be used without permission from Project Cities.

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City of Peoria
and Project Cities

ACKNOWLEDGMENTS

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On behalf of the Julie Ann Wrigley Global Futures Laboratory, the Global Institute of Sustainability and Innovation, and the School of Sustainability, we extend a heartfelt thank you to the City of Peoria for enthusiastically engaging with students and faculty throughout the semester. These projects provide valuable real-world experience for our students and we hope that their perspectives shine light on opportunities to continuously improve Peoria's future livelihood and community well-being.

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To access the original student reports, additional materials, and resources, visit:

links.asu.edu/PCPeoriaElectricFleet22F

ABOUT PROJECT CITIES

The ASU Project Cities program uses an innovative approach to traditional university-community partnerships. Through a curated relationship over the course of an academic year, selected community partners work with Project Cities faculty and students to co-create strategies for better environmental, economic, and social balance in the places we call home. Students from multiple disciplines research difficult challenges chosen by the city and propose innovative sustainable solutions in consultation with city staff. This is a win-win partnership, which also allows students to reinforce classroom learning and practice professional skills in a real-world client-based project. Project Cities is a member of Educational Partnerships for Innovation in Communities Network (EPIC-N), a growing coalition of more than 35 educational institutions partnering with local government agencies across the United States and around the world.

ABOUT SUSTAINABLE CITIES NETWORK

Project Cities is a program of ASU's Sustainable Cities Network. This network was founded in 2008 to support communities in sharing knowledge and coordinating efforts to understand and solve sustainability problems. It is designed to foster partnerships, identify best practices, provide training and information, and connect ASU's research to front-line challenges facing local communities. Network members come from Arizona cities, towns, counties, and Native American communities, and cover a broad range of professional disciplines. Together, these members work to create a more sustainable region and state. In 2012, the network was awarded the Pacific Southwest Region's 2012 Green Government Award by the U.S. EPA for its efforts. For more information, visit *sustainablecities.asu.edu.*

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Sustainability through local action

ABOUT PEORIA

Ranked as the No. 1 place to live in Arizona by Money Magazine, the City of Peoria is currently home to over 190,000 residents. The City enjoys a reputation as a family-oriented, active community with an exceptional quality of life. Peoria entertainment and recreational amenities include attractions such as Lake Pleasant, trails, and community parks.

The City has also demonstrated a strong commitment to sustainability, as evidenced by its incorporation of LEED building design standards, a council-adopted Sustainability Action Plan, and the "Green Team" staff dedicated to managing organization-wide sustainability initiatives.

PEORIA TEAM

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Peoria is the place
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February 28, 2022

Dear Peoria community members,

On behalf of the City of Peoria, we would like to express our appreciation to all who have been involved with Arizona State University's (ASU) Project Cities program. Over the last year, our staff has had the opportunity to collaborate with faculty and students across several academic programs, benefitting from their insights, ingenuity, and diverse perspectives on a number of projects. Many of these entailed public participation, and you may have met some of these engaging students at a community event, or completed a community survey.

Project Cities is one of several partnerships we enjoy with ASU, and part of our ongoing strategy to connect with community partners to leverage our resources as we address the many challenges facing local governments. Working with students at an undergraduate, graduate and capstone project level brings a fresh perspective and resourcefulness to complex issues. This partnership has resulted in extensive research, recommendations, and deliverables that take several key initiatives to the next level. These include our efforts around increasing transit ridership, community engagement strategies, historic preservation and innovative recycling methods. Through this partnership, we have developed an understanding of the feasibility of each initiative much more quickly than we could have without their collaboration.

The results provided on each project position us to serve our community with cost-effective and innovative programs in the interest of continuous improvement. The city has already begun to incorporate the students' deliverables into next steps in advancing these projects. We look forward to continuing this work on additional projects in the coming year with such talented students and faculty.

The City of Peoria appreciates the ongoing and growing relationship with Arizona State University and the many ways in which the alliance provides mutual value.

Sincerely,

Cathy Carlat, Mayor

Jeff Tyne, City Manager

Peoria, Arizona

Proud partner of

ASU Sustainable Cities Network

Arizona State University

Project Cities

Rio Vista Recreation Center

Demographics

total population: **190,985**

median age: **35**

highly skilled and educated workforce of 85,252

11,997 veterans live in Peoria

78% of residents are homeowners

median property value: **$399,025**

33% of residents hold a Bachelor's degree or higher

median household income: **$79,700**

Schools

#3 of 131 Best School Districts for Athletes in Arizona

#5 of 40 Best School Districts in Phoenix Metro Area

#7 of 130 Best School Districts in Arizona

The Peoria Unified School District consistently receives high ratings and offers signature programs such as the Career and Technical Education programs. Deer Valley Unified School District has two highly-rated K-8 schools within the city, including an Academy of Arts.

Peoria is also home to Huntington University, a liberal arts college offering digital media education in animation, broadcasting, film, graphic design and other digital media arts.

Leading industries

Peoria, Arizona is not just a scenic suburb of Phoenix, but also a thriving economic development hub with an educated workforce and high-end residential living. There are over 4,000 employers and more than 75,000 people employed within Peoria. Leading industries include health care and social assistance, retail trade, and finance and insurance. Highest-paying industries include utilities, manufacturing and public administration. Beyond these industries, Peoria works actively to attract businesses from aerospace and defense, film and digital media, technology and innovation, hospitality and tourism, and research and development. Peoria is the place for business owners, developers and investors.

Health Care & Social Work

10,905 employees

Retail Trade

10,628 employees

Finance & Insurance

6,574 employees

History

Founded in 1886 by Midwestern settlers, Peoria is nestled in the Salt River Valley and extends North into the foothills around Lake Pleasant. Beginning as a small agricultural town, the economy received a major boost when a railroad spur line was built along Grand Avenue. The construction of the Roosevelt Dam in 1910 secured a reliable water supply, attracting more settlers to the area and business endeavors to the town center. Peoria's economy continued to have an agricultural focus for decades. Continually growing, Peoria assumed city status in 1971 with a population of 4,792. It has since grown into a city with a population over 190,000, and is renowned for its high quality of life and recreational amenities.

Sustainability

Peoria has demonstrated leadership in municipal sustainability efforts through a wide range of actions. Listed below are some of the City's sustainability accomplishments.

- Incorporation of LEED building design standards
- Appointment of a full-time city staff member who manages and coordinates sustainability initiatives
- Sustainable urban planning practices including open space planning and water management principles
- Sustain and Gain: Facebook page and brochures keep residents up to date on city sustainability efforts and ways to get involved
- Water Conservation Program: free public classes, public outreach at city events, and water rebate incentives for residents
- Council-Adopted Sustainability Action Plan: this strategic planning document, in its second iteration, ensures city departments are developing sustainability-oriented goals, tracking success metrics, and encouraging cross-communication in the preparation of Sustainability Update presentations made to the Peoria City Council on an annual basis
- Sustainable University: courses and workshops to empower residents to make small changes that make Peoria a better place to live; topics covered include residential solar, gardening, composting and recycling

Awards and recognition

- Award of Distinction for Technology Innovation, ROBO Ride Autonomous Vehicle Project, 2022 *(Arizona Forward)*
- Best Neighborhood Program for Social Revitalization/ Neighborliness, 2022 *(Neighborhoods USA)*
- No.1 City to Live, Work and Play in 2021 *(Ranking Arizona)*
- Outstanding Facility Award for Paloma Community Park, 2021 *(Arizona Parks & Recreation Association*
- Best of the West Excellence in Innovation Award for Pop-up Peoria, 2021 *(Westmarc)*
- Top 15 Safest Cities in the U.S. 2017-2019 *(Wallethub)*
- 10th Best City to Raise a Family in 2018 *(Wallethub)*

Lake Pleasant

1886 — **2020**

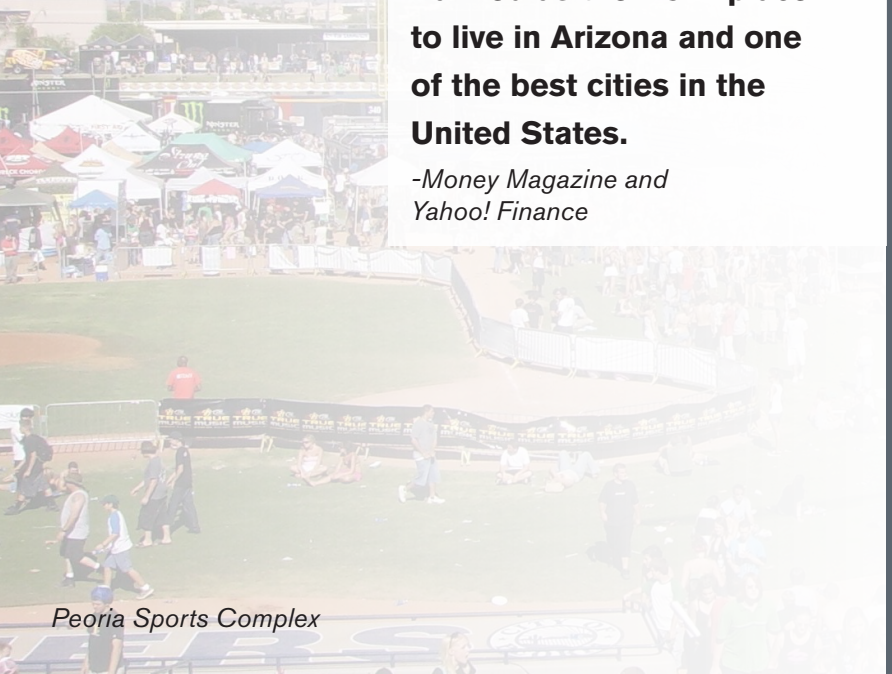
- **1889** — Peoria founded by William J. Murphy
- **1889** — First school district formed
- **1919** — Chamber of Commerce organized
- **1954** — Assumed city status with a population of 4,792
- **1954** — Peoria incorporated
- **1971** — Centennial celebration
- **1977** — Brewers spring training begins at Greenway Sports Complex
- **1986** — Theater for the Performing Arts and Rio Vista Recreation Center opened
- **1994** — Peoria Sports Complex opened
- **2007** — 20-year extension spring training agreement with San Diego Padres and Seattle Mariners
- **2012** — Selected as site of new $70M health clinic for Maricopa County Integrated Health System
- **2017**

Livability

Peoria is renowned as a great place to raise a family and start a career. A plethora of local amenities and attractions contribute to Peoria's livability. Beyond the tourist attractions of Spring Training and Lake Pleasant, the City offers many community facilities and recreational opportunities for all ages and interests such as an extensive public park system and annual community events. Peoria's dedication toward livability is also evident in the City's latest General Plan which addresses sustainable water use, housing, public services and more.

Ranked as the No. 1 place to live in Arizona and one of the best cities in the United States.

-Money Magazine and Yahoo! Finance



Peoria Sports Complex

Peoria strives to uphold these six major livability priorities in order to maintain an exceptional quality of life for its citizens:

- Arts, Cultural and Recreational Enrichment
- Economic Prosperity
- Smart Growth
- Superior Public Services
- Healthy Neighborhoods
- Integrated Transportation

Community Facilities

- Peoria Community Center
- Rio Vista Recreation Center
- Peoria Sports Complex
- Peoria Center for the Performing Arts
- 39 neighborhood parks
- 2 libraries
- 3 swimming pools
- 5 golf courses
- 9 lighted multi-purpose ball fields
- 15 tennis courts

Lake Pleasant

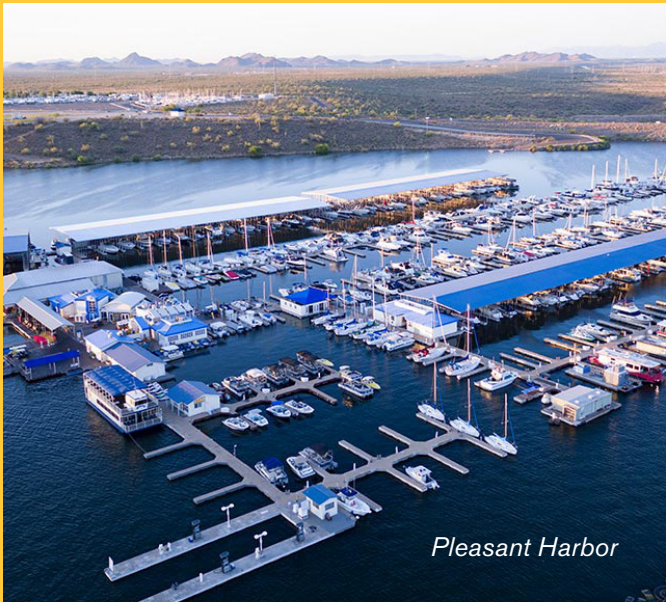
Urban ecology, ecotourism and recreation

Peoria is surrounded by the natural beauty of the Sonoran Desert and is home to Lake Pleasant, a 23,000-acre park and major recreational asset to the North Valley. The transient Agua Fria River and New River flow through Peoria, as do a multitude of washes and creeks. Most notable perhaps is Skunk Creek — known for the recreational trails running alongside it — which forges a connection between Peoria and Glendale. Northern Peoria is home to beautiful mountains and buttes including Sunrise Mountain, Calderwood Butte and Cholla Mountain.

Boasting over 300 days of sunshine annually, Peoria's ecotourism opportunities are a steady industry for residents and visitors. The City features over 60 miles of trails for walking, biking and horseback riding, as well as 570 total acres of accessible park land.

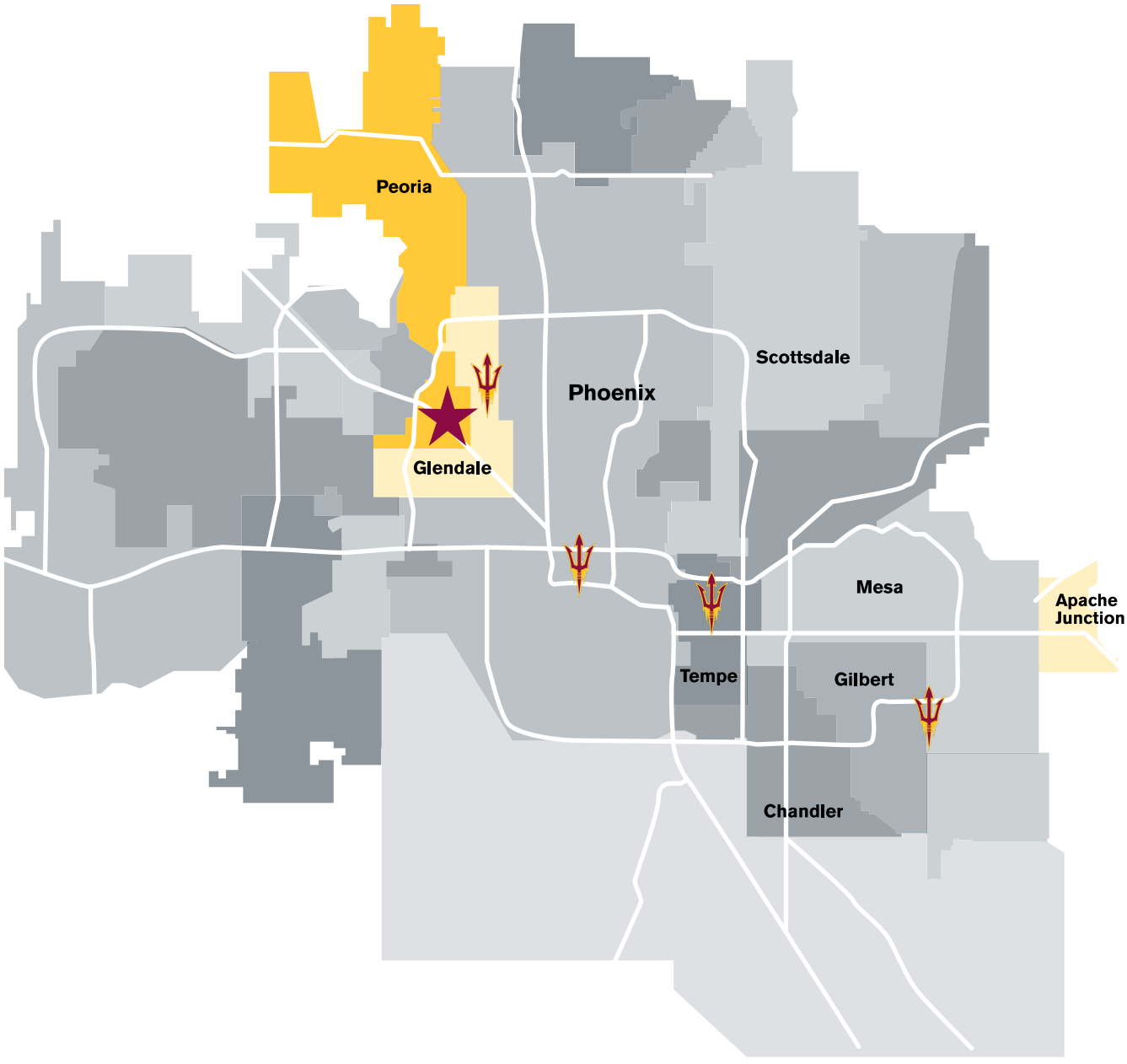
Lake Pleasant Regional Park contains a full-service marina, providing opportunities for water-oriented recreation such as kayaking, water skiing and even scuba diving. Visitors can also go horseback riding, take gliding lessons, hike, camp and more.

Skunk Creek



Pleasant Harbor

MAP OF PROJECT CITIES PARTNER COMMUNITIES IN THE GREATER PHOENIX METROPOLITAN AREA



Peoria City Hall

ASU campus

The following report summarizes and draws highlights from work and research conducted by students in SOS 324: Sustainable Energy Technology & Systems for the Fall 2022 partnership between ASU's Project Cities and the City of Peoria.

To access the original student reports, additional materials, and resources, visit:

links.asu.edu/PCPeoriaElectricFleet22F

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EXECUTIVE SUMMARY

The City of Peoria staff and leadership are committed to evolving to meet the needs of its growing community, while searching for innovative and strategic opportunities to optimize its services. Peoria's municipal fleet includes a wide range of vehicles to support the City's services, including emergency vehicles, public transportation, and public works vehicles. The City also supports a wide range of City-operated light-duty vehicles that provide transportation for Peoria staff to various sites throughout the City.

As electric vehicles gain popularity for their ability to reduce vehicle emissions and minimize long-term maintenance costs, especially with increasing flexibility of charging infrastructure, the City of Peoria is interested in addressing the sustainability of its municipal fleet and is specifically looking to adapt its fleet to include electric vehicles. Considering the existing fleet infrastructure, the City is interested in the associated costs and infrastructure needed to support the adoption of electric fleet vehicles, as well as opportunities for optimized charging locations.

Figure 1 *Aerial view of City of Peoria, by City of Peoria*

Nathan Parker's **SOS 324 Sustainable Energy Technology & Systems** course coordinated with Peoria's Fleet Manager to recommend strategies to electrify Peoria's municipal fleet. Using the inventory of Peoria's fleet vehicles, students analyzed the long-term costs associated with replacing City vehicles with electric vehicles,

considering the cost of purchasing EV charging stations and the ages of the vehicles. From this analysis, students recommend a “Near Future” plan to gradually roll out fleet vehicles, with the goal to electrify 15% of Peoria’s fleet in the next 10 years.

The following report summary and recommendations provide the City of Peoria with a baseline plan for transitioning its municipal fleet, with short-term and long-term recommendations for the City of Peoria to consider in its sustainability and transit planning.

KEY STUDENT RECOMMENDATIONS

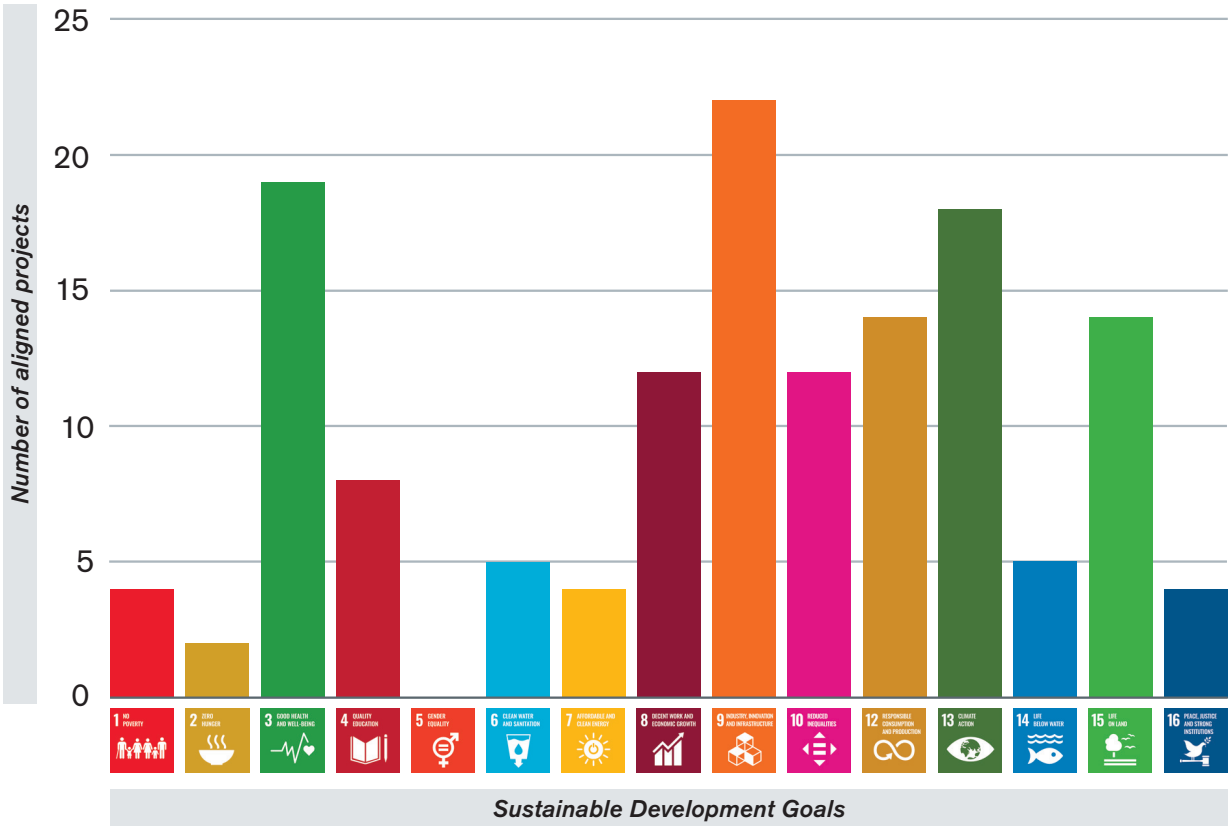
Recommendations for Fleet Electrification Strategies	Read more
Near Future Scenario (approx. 10 years)	
▪ Set a goal of electrifying 15% of the City's total fleet, requiring the purchase of approximately eight new EVs per fiscal year.	pp.35-40
▪ Install 50 Level 2 chargers in areas with the most EV activity.	pp.35-40
Mid-Future Scenario (approx. 30 years)	
▪ Set a goal of electrifying 40-50% of the City's total fleet, coinciding with the expected trend of battery costs declining and EV options increasing.	p.40
▪ Install 150 total Level 2 chargers, three Solar Arc Stations, and two Level 3 high-capacity chargers. These should be placed on critical infrastructure points as the need for more chargers in urban areas decreases.	p.40
Far Future Scenario (approx. 50 years)	
▪ Set a goal of electrifying 100% of the City's total fleet, with the expectation that markets will stabilize and pricing will decrease with supply.	p.40
▪ Install 300 total Level 2 chargers, 10 Solar Arc Stations, and eight Level 3 high-capacity chargers. These should fill the gaps between the critical infrastructure points, and the Level 3 chargers should be mainly placed close to high volumes of traffic.	p.40

CITY OF PEORIA PROJECTS: ALIGNMENT WITH THE UNITED NATIONS' SUSTAINABLE DEVELOPMENT GOALS

As the leading international framework for sustainable decision-making, the 17 Sustainable Development Goals (SDGs) lay out a path for partnerships toward global peace and prosperity. The SDGs provide a set of goals and metrics for project impact to be measured, offering an illustration of the benefits experienced by the cities, towns, and students who participate in a Project Cities partnership. For details on the SDGs, visit **sdgs.un.org/goals.**

Every project in the PC program aligns with SDGs 11 and 17.

The figure below illustrates SDG project alignment throughout the City of Peoria's partnership with Project Cities, through the Fall 2022 semester.



TOP THREE GOALS ADDRESSED IN THE FOLLOWING REPORT

Transportation is a critical piece of a community's infrastructure. The student analysis covers two critical topics related to community well-being: a well-connected transportation system that seeks to serve the larger community and a sustainable transition to electric vehicles. This project contributes to the advancement of several SDGs, including SDG 9, SDG 11, and SDG 13.

Goal 9: Industry, Innovation and Infrastructure

"Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation."

Transitioning Peoria's fleet vehicles to electric vehicles with implementation of on-site charging stations provides a more resilient infrastructure for the City's fleet management.

Goal 11: Sustainable Cities and Communities

"Make cities and human settlements inclusive, safe, resilient and sustainable"

Electrifying its fleet provides an opportunity for Peoria to sustainably manage its municipal operations and provide its employees with sustainable alternatives to conventional internal combustion engines.

Goal 13: Climate Action

"Take urgent action to combat climate change and its impacts"

Integrating alternative energy options for the City's municipal fleet seeks to reduce on vehicle emissions and prioritize sustainable development.

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PART 2:

Fleet Electrification Strategies

EXPLORING PATHWAYS TO ELECTRIFY A MUNICIPAL FLEET

SOS 324:
SUSTAINABLE ENERGY TECHNOLOGY & SYSTEMS

COLLEGE OF GLOBAL FUTURES

FACULTY
NATHAN PARKER

ACKNOWLEDGMENTS

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INTRODUCTION

The City of Peoria prioritizes its family-friendly atmosphere and quality of life aspects that lend the City its title as the Best Place to Live, Work and Play (City of Peoria, 2021). As a growing community, the City has over 500 vehicles in its fleet, all of which contribute greatly to the City's outstanding public services. With a large fleet, electrification of its municipal fleet could contribute positively to City's goals set forth by its General Plan 2040, including its Livability Initiatives that outline priorities for the City, such as Smart Growth and Integrated Transportation. Introducing more electric vehicles (EVs) could alleviate some of the challenges of conventional combustion engines, such as impacted air quality and associated health issues.

"To guide future growth and development into a sustainable citywide development pattern, while maintaining or enhancing quality of life in our communities. Growth should be at a desired scale and character that is consistent with the social, economic and aesthetic values of the City."

"To holistically create a seamless network of mobility choices, through acknowledgment and dedication to continuing to foster and grow the on-street roadways, off-street shared use paths, transit options, and plan for advancing technologies. Transportation should be considered for all modes of travel and universally accessibility."

Figure 1a and 1b *City of Peoria Livability Initiatives, Smart Growth and Integrated Transportation, Peoria General Plan 2040*

Electric vehicles can contribute to a reduction in tailpipe emissions and can utilize renewable energies, such as solar, which is plentiful in the Valley. **Integrated Transportation** calls for developing, enhancing, beautifying, and expanding all current transportation options and exploring emerging technologies. Fleet electrification is a step in the right direction as it reduces the number of pollutants in the air while preparing for what the future will bring for new transportation technologies. Superior public services are, in large part, responsible for the overall well-being of the communities residing in Peoria. Ensuring that service is safe and secure for residents is paramount, so updating the tools to do so should be prioritized to continue meeting those goals. Optimizing

Editor's Note
An Integrated Transportation System comprises a territory and the offering of transportation, where multiple modes coordinate with each other to set schedules, pricing, and other validation systems.

the City's fleet through a phased process of replacing existing vehicles with electric vehicles can help Peoria staff, leadership, and residents adjust and learn about these new technologies before exploring further the opportunities provided by a fully electrified municipal fleet. As Peoria focuses on the goals of the General Plan Update and its 2040 Vision Statement, fleet electrification is a desired step towards meeting or exceeding these goals.

After developing a thorough understanding of how the current fleet functions, the team identified suitable electric vehicle alternatives that were available now or in the near future. After careful calculations, the team determined the viability of these alternatives and compared them with their gas-powered counterparts. Students also identified potential areas for charging stations for the electrified fleet.

LITERATURE REVIEW

Editor's Note
Fleet vehicles are a group of vehicles owned or rented by an organization, like a government agency.

Many cities across the United States are embarking on the transition to electric vehicles, often starting with their municipal fleet vehicles. The Electrification Coalition has developed a policy toolkit for electric vehicle adoption and deployment at the local level that outlines useful policies surrounding charging infrastructure and multi-sector, freight, fleet, and consumer electric vehicles. In addition to their policy recommendations, the Electrification Coalition provides multiple examples of cities that have started electrifying their fleet. For example, Pittsburgh set a goal of a 100% fossil-fuel-free fleet by 2030, in addition to powering the fleet with renewable energy that has been locally produced or purchased (Electrification Coalition, 2021).

Editor's Note

The Electrification Coalition researches and designs strategies for the adoption o→f electric vehicles. The Coalition houses a comprehensive electric vehicle policies toolkit to advise on local, state, and federal adoption of EVs.

An academic case study in Pittsburgh compared four vehicle types on costs, greenhouse gas (GHG) emissions, and nitrous oxide emissions (Mersky & Samaras, 2020). The vehicles compared in the study are internal combustion engine (ICE) vehicles, hybrids, plug-in hybrids, and battery-electric vehicles. The study found a roughly $7,000 price trade-off for lower emissions. Battery electric vehicles emitted the fewest

greenhouse gases and nitrous oxides in multiple scenarios compared to the other options. However, battery electric vehicles had a higher 15-year private cost than ICE and hybrid vehicles. The ICE and hybrid vehicles had approximately the same 15-year private costs at around $33,000, lower than plug-in hybrids at $45,000 and battery electric vehicles at $40,000. Despite the cost difference, Pittsburgh plans to move forward with its goal of a 100% fossil-fuel-free fleet by 2030.

Figure 2 *Charging station for an Electric Vehicle (EV) in Pittsburgh, by PittsburghTriblive*

As a part of its charging infrastructure, Pittsburgh plans to install solar panels above its parking lots, as "the installation of PV on the city-owned parking facilities in downtown Pittsburgh could potentially power the equivalent of 40 million km of electric vehicle travel per year; more than 30 times the yearly travel of the city's municipal nonemergency light-duty vehicle fleet," according to Mersky & Samaras (2020). The additional energy could be a useful way to integrate charging infrastructure for residents that will hopefully follow the Pittsburgh's example in the transition to electric vehicles. A city can bolster its transportation electrification efforts by reducing barriers to developing a strengthened infrastructure while garnering public and private support for EVs (Electrification Coalition, 2021).

An article from researchers at Northwestern University projected that carbon dioxide and nitrogen dioxide emissions would fall due to fleet electrification, improving community health in Chicago (Montgomery et al., 2021). An example of how effective electrification efforts have been is found in a review of countermeasures used by German cities to reduce

emissions. Over half of the cities examined are prioritizing electrification, especially those with a population between 250,000 and 500,000 residents (Johnsen et al., 2019).

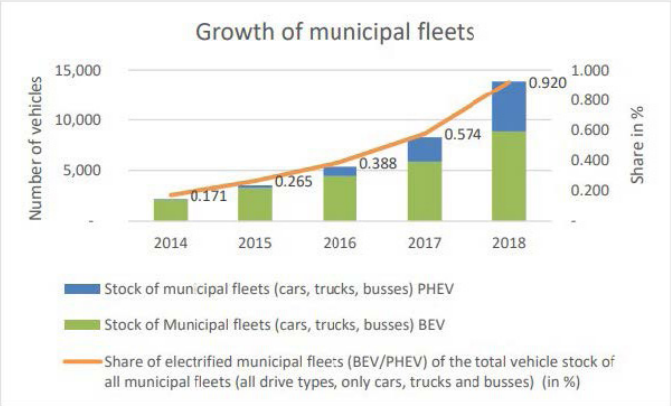


Figure 3 *Growth of municipal electric fleets, by Johnsen et al., 2019*

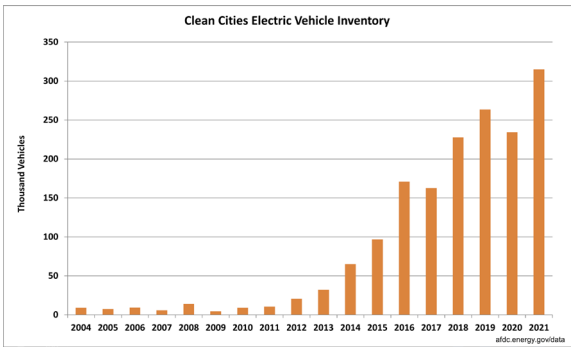


Figure 4 *Growth of electrified municipal fleets in the United States, by U.S. Department of Energy, 2022*

Editor's Note

To meet the increasing demand for electric vehicles, solar canopies can be installed to capture solar energy to charge electric vehicles.

In order to examine the economic trade-offs of facilitating large-scale electrification, a team of researchers examined the implementation of photovoltaic installation to support fleet electrification and found that there was a large change between the best-case scenario (net present value of two million) and the worst-case scenario (net present value loss of eight million). Furthermore, the use of solar canopy supports to install photovoltaics in parking lots would cause this net present value loss to increase significantly (Mersky & Samaras, 2020). Electric vehicle technologies are still developing and are not yet fully implementing at scale; however, as they are implemented and scaled, more case studies

can be produced, allowing for a better understanding of the feasibility of electrification based on the specific context of each municipality considering this complex undertaking.

RESEARCH METHODS

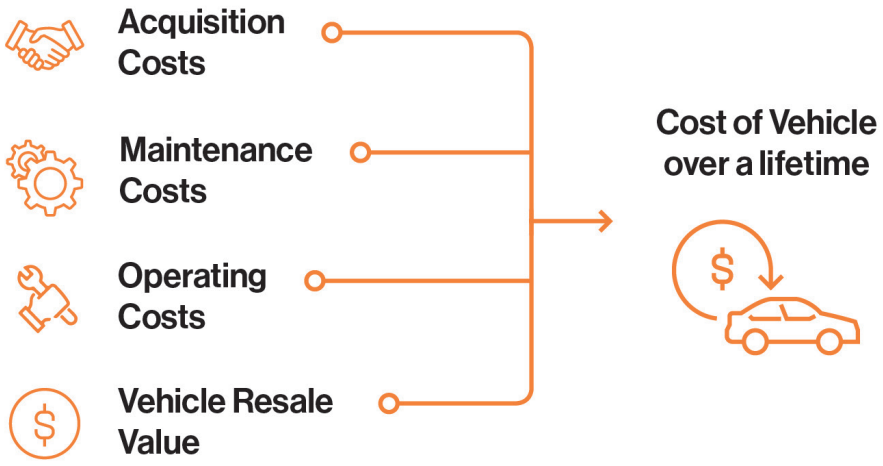
Peoria's fleet was categorized into 11 overarching categories to determine the best type of vehicle for a replacement for each type of vehicle classification. The following categories are listed below, with the corresponding vehicle count for the category based on fleet data provided by the City of Peoria. Law enforcement vehicles were not included in the data since the City determined that law enforcement vehicles were not candidates for electrification at this time.

City of Peoria fleet vehicles inventory			
Vehicle Type	***EV Replacement***	***ICE Vehicle***	***Quantity***
Sedan	Chevy Bolt	Chevy Malibu	31
Sport Utility Vehicle	VW iD.4	Ford Edge	70
Passenger Van	Mercedes Benz eVito Tourer	Toyota Sienna	13
Cargo Van	Ford eTransit	Ford Transit	25
Light-Duty Truck	Chevy Silverado EV	F-250 XLT	48
Medium-Duty Truck	F-150 Lightning	Ford F-350	17
Half-Ton Truck	F-150 Lightning	F-150	172
Bus	ARBOC Esquees Charge or Ford eTransit	ARBOC	6
Marked SUVs	N/A	Ford Explorer	35
Heavy-Duty Truck	N/A	Peterbilt 520	47
Class 4-6 Trucks	N/A	Ford E450, 550, 650	40
		Total:	**504**

Figure 5 *Peoria fleet vehicles inventory*

Total Cost of Ownership

To calculate the total cost of ownership (TCO) over a vehicle's lifetimes, students organized Peoria's fleet data and used that information for calculations. Based on vehicle classifications and the given cost data, EV replacements were found based on logical and cost-based decisions. For both EV and the conventional ICE vehicles, acquisition costs, maintenance costs, operating costs, and the vehicle's current value were all gathered to assess the costs of the vehicles over the lifetime. The operation and maintenance costs, along with the fuel costs, were calculated by using the annual averages.



Editor's Note

Salt River Project, SRP, and Arizona Public Service, APS, are utility providers in Arizona. City of Peoria, SRP, and APS were able to provide usage data to students to inform the project.

A summation is applied to account for all costs. Peoria's data on current fleet usage, annual miles driven, and annual fuel costs were extracted in the calculations. To accurately calculate the cost of operating and using an EV, the electricity costs for charging in certain areas were calculated based on the respective SRP and APS rates and the miles per kilowatt hour (kWh) the respective vehicle can travel. The rates were matched to locations based on the data provided from the City's electricity bills; the locations and their respective rates were included in the final calculations. The application of this information allowed the students to calculate the TCO for the conventional, in-use ICE vehicles and the EV replacements and find the differences between the two costs. Subtracting the TCO for ICE vehicles from the TCO for EVs yields savings in positive numbers and losses in negatives.

(1) $$EV\ Savings = TCO_{ICE} - TCO_{EV}$$

(2) $$TCO_{EV} = PP_{EV} + \frac{Charger\ Cost * CPW}{5} - Tax_{Credit} + \sum_1^T \frac{O\&M+FC}{(1+r)^t} - \frac{Salvage\ Value}{(1+r)^T}$$

(3) $$TCO_{ICE} = PP_{ICE} + \sum_1^T \frac{O\&M+FC}{(1+r)^t} - \frac{Salvage\ Value}{(1+r)^T}$$

(4) $$CPW = \frac{Electricity\ consumption\ per\ year\ (kWh)}{52\frac{weeks}{year} * 66\frac{kWh}{charge}}$$

TCO: Total Cost of Ownership

PP: Purchasing Price

CC: Cost of charger

CPW: number of charging events per week

O&M: Annual Operating and maintenance costs

FC: Annual fuel or electricity cost

t: year

T: useful life

Salvage Value: 15% of PP

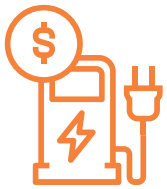
The number of chargers needed to supply the EVs was found by determining the number of charging events per week needed to power each EV. A **charging event** is an overnight parking event at a Level 2 charger that would provide up to 66 kWh to the vehicle. A charger is needed for every five weekly charging events at a given location. Every vehicle has at least one charging event per week. The costs of chargers were calculated by taking the installation cost for the respective chargers and adding the annual average maintenance costs. The lifetime of the charger is also factored into the cost.

Figure 6 *DC Fast Charging Stations*

The TCO was the chosen operation for the calculation because comparing only acquisition costs is not enough information to show which vehicles would be more cost-efficient in the short- and long-term. Many of Peoria's newer fleet vehicles were not currently viable options for replacement, thus vehicles closer to retirement age and vehicles that travel a significant amount of miles per year emerged as the most viable option for EV replacement.

Fleet electrification implementation

Identifying the locations for the chargers for the first phase of implementation was based on which ICE vehicles would be replaced by electric vehicles first. After calculating the TCO, students devised an implementation plan that identifies ideal vehicles for replacements based on a set of criteria, including the total cost of charging station installation, total years until vehicle retirement, projected GHG emissions, and projected total electricity demand at each facility.

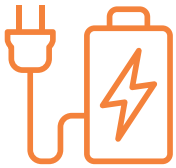


Cost of charging stations

The cost for the charging stations was determined by the highest estimated cost for installation of the chargers multiplied by the number of charging stations placed at the location, plus the price per charger, multiplied by the number of charging stations. The total cost of annual maintenance of the chargers was determined by the maintenance cost multiplied by the number of chargers.

Projected GHG emissions

The estimated average GHGs saved through electrification was calculated based on data from the current conventional ICE vehicles in use. The average CO_2 emissions saved per mile were calculated based on the combination of vehicles in each classification and their respective CO_2 emissions per mile.



Projected electricity

The projected electricity demand increases were found by aggregating the estimated charging needs of all-electric vehicles at each location. Changes in the demand charge, a portion of some of the monthly electricity bill

based on the maximum power demand for the given month were not directly factored into the calculations due to their variability.

The internal combustion engine cost of ownership minus the electrical vehicle net present cost determined the electrical vehicle savings. The data was filtered based on positive saving rates and the retirement year of the vehicle between one and five years. Additionally, this data was filtered by vehicle classification, to remove vehicle classes without a good EV option.

FINDINGS & ANALYSIS

The vehicles recommended for electrification would be those currently parked at the Peoria Municipal Operations Center (MOC), fire stations, and the Development and Community Services Building (DCSB). Since this recommendation emphasizes on placing more chargers at the MOC and DCSB, and not the fire stations, the cost comparison is limited to vehicles at the MOC and DCSB. There are 98 vehicles at the MOC and DCSB that are worth replacing over the vehicle lifetime, given the current rate of electricity and EV acquisition costs, most of which are within the SUV or light-duty truck classifications. The recommended EV vehicles for these classifications are the VW iD.4 and the Ford F-150 Lightning.

Figure 7 *Volkswagen iD.4*

City of Peoria fleet vehicles inventory					
Equipment ID	***Classification***	***Location***	***Year***	***Model***	***Lifetime Savings***
2218	Half-Ton Truck	MOC	2018	Ford F-150 Super CRW	$44,126
2119	Medium-Duty Truck	MOC	2017	Ford F-350	$40,375
1875	Light Duty-Truck	MOC	2015	Ford F-250	$30,384
2014	Medium-Duty Truck	MOC	2016	Ford F-350	$28,137
2292	Cargo Van	MOC	2019	Ford E-350	$24,545
1783	Light-Duty Truck	MOC	2013	Ford F-250	$22,539
2225	Light-Duty Truck	MOC	2019	Ford F-250 Super Duty	$22,080

Figure 8 *Proposed vehicles for EV replacement*

The Chevrolet Tahoe, Ford F-150 Super CRW, Ford F-350 and the F-250 would be the most cost-effective for EV replacement. These vehicles are all relatively close to their retirement years, which is a major factor in the estimate of their cost savings.

At the proposed charger site of the MOC, two DC fast charging stations and 12 Blink IQ200 Level-2 Chargers are recommended at the same site. At the DCSB, four Blink IQ200 Level-2 chargers are recommended. The primary type of charging station chosen was the Blink IQ200 Level-2 chargers, as this type of charger is suitable for a wide variety of charging needs while maintaining affordability. Blink IQ200 Level-2 chargers have a 12-20 kW charge and two plugs, an installation cost of approximately $6,000, an annual maintenance cost of $400, and a lifetime of 10 years, and price per charging station of $2,739. The start-up installation costs of the 12 IQ200 Blink Level-2 chargers at the MOC are estimated to be $407,188, and the total annual maintenance costs are estimated to be $5,600. For the two chargers at the DCSB, the estimated startup installation costs are estimated to be $34,956 and total annual maintenance costs are estimated to be $1,600.

Figure 9 *Blink IQ200 Level-2 chargers*

Figure 10 *DC Fast Charging Stations*

In addition to the Blink IQ200 Level-2 charters, DC fast charging stations were selected because they have a higher charge rate at 175kW and two plugs, an 80% efficiency rate, an annual maintenance cost of $400, and a 10-year life expectancy. However, only two of the DC Fast Charging Stations would be installed at the MOC due to estimated $80,000 price of installation, with each charger costing an additional $70,000.

In total, there would be 18 charging stations, 14 at the MOC, and four at the DCSB. The total cost for the Blink IQ200 Level-2 chargers for both locations is approximately $104,388, while the total cost for the DC fast charging stations for both locations is approximately $302,800. The annual maintenance cost of the chargers would be $5,600. The approximate cost for the total startup for the MOC is $407,188. As for the DCBS, there was the recommendation of adding four Blink IQ200 Level-2. These chargers cost approximately $34,956; the total startup cost would be $34,956. While the annual maintenance cost would be $1,600.

From the calculations, replacing the fleet buses with an EV would save the most CO_2 per mile, but the TCO of replacing the buses would result in a loss over time since the new electric buses are relatively expensive. Fortunately, the SUV, light-duty, medium-duty, and half-ton trucks all have notable CO_2 per mile saved on average. There are multiple viable, cost-effective options for replacing these classes so GHG emissions could be reduced with savings.

Classification	Average CO_2 emissions saved per mile
Sedan	386 grams CO_2 per mile
Light-Duty Truck	470 grams CO_2 per mile
Half Ton Truck	555 grams CO_2 per mile
Medium-Duty Truck	614 grams CO_2 per mile
Cargo Vans	552 grams CO_2 per mile
Bus	1000 grams CO_2 per mile
Passenger Van	253 grams CO_2 per mile
SUV	592 grams CO_2 per mile

Figure 11 *Estimated average CO_2 emissions saved per mile*

For the MOC, around 379,566 kWh per year would be required to charge the viable EV alternatives. Based on the approximate cost for overnight charging at the MOC (SRP rate 36), this annual input would cost around $22,773 per year. For the DCSB, around 123,301 kWh per year would be required to charge the replacement EVs based on the annual average miles traveled. Based on the APS rate and the designated rate for overnight charging, approximately $8,600 is necessary annually to meet the vehicle charging demands for full electrification.

Based on the average savings, most, but not all of the vehicles would be more costly to replace with an EV in the long term, resulting in a net loss of around $11K over all the vehicles' lifetimes. As the City of Peoria, along with many cities throughout the U.S., are interested in fleet electrification, it is important to consider the short- and long-term costs and benefits of such a transition. Thus, it is recommended for Peoria to consider a phased approach to fleet electrification, as described in the following section.

RECOMMENDATIONS

Based on the estimations, the City of Peoria can electrify 15% of its current fleet. Considering a total of 504 vehicles in the fleet, roughly 15 vehicles would have to be replaced with an EV every year. In the "Near Future Scenario", a recommended schedule maps out which vehicles to replace over the next five years, the estimated cost, and the GHG emission savings.

Near Future Scenario

Before electrifying the majority of Peoria's fleet, chargers will need to be installed at the locations where the fleet vehicles are parked and stored. While the few existing electric vehicles in the fleet are using the public Blink chargers, this is not an efficient or viable long-term option for supporting the electrification of the entire fleet. As many of the fleet vehicles suggested to be replaced with EVs are parked at the MOC and DCSB, these locations should be prioritized for charger installation. The recommendation for the chargers at the Development and Community Service Building:

1. Four IQ200 Blink Chargers Level-2

Figure 12 *Map of the recommended locations for new EV charging stations at Development and Community Services Building*

The recommendation for the chargers at the Municipal Operation Center is a total of 14 Blink and DC Fast Chargers:

1. Two DC Fast Charging Stations should be placed near the north side of the building for electric transit buses.
2. Four IQ200 Blink Chargers Level-2 near the south side of the building.
3. Four IQ200 Blink Chargers Level-2 near the fleet maintenance shop.
4. Four IQ200 Blink Charger Level-2 near the middle of the location.

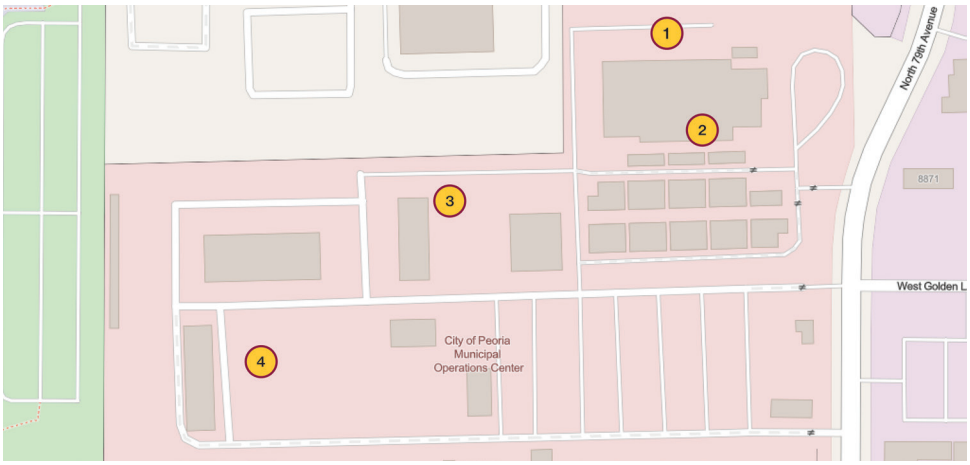


Figure 13 *Map of the recommended locations for new EV charging stations at Municipal Operation Center*

The recommended electric vehicle roll-out is based on the vehicles that offer the highest EV savings that are located at the MOC and the DCSB and are scheduled for retirement. Scheduled retirement years were prioritized in the roll-out to align with the City's existing schedule for vehicle replacement.

Year 1

- Within the next year, it is recommended to replace 8 vehicles with an EV (Figure 14). While these vehicles may not offer the highest overall savings, these vehicles are past retirement or scheduled for retirement.
- In the near term, these are trucks that would be replaced with a Ford F-150 Lighting.
- If limited availability of the Ford F-150 Lightning makes this difficult, consider the sport utility vehicles listed in Year 2 for Year 1. These vehicles would save $15,750 on average over their life and save 24,000 kg per year of greenhouse gases.

Equipment ID	Location	MY	Model	EV Savings
1783	MOC	2013	Ford F-250	$25,423
1720	MOC	2012	Ford F-250 Super Duty	$21,173
1724	MOC	2012	Ford F-250 Super Duty	$18,789
1759	MOC	2013	Ford F-250	$14,484
1792	DCSB	2013	Nissan Frontier	$14,219
1858	MOC	2014	Ford F-250 Super Duty	$12,385
1194	DCSB	2005	Ford F-250	$10,168
1859	DCSB	2014	Ford F-250	$9,176

Figure 14 *Equipment model and EV savings*

Year 2

- The recommended rollout for the next year includes replacing a mix of SUVs with the VW iD.4 and pickup trucks with the Ford F-150 Lighting. These vehicles offer higher savings than those in the first year but are two years from retirement. In particular these are high mileage vehicles that are located at the Municipal Operations Center.
- Assuming their ICE vehicle replacement would be a Ford Edge or F-150, the total savings from these nine replacements would be $232,700. Replacing these vehicles would save over 37,000 kg/year of GHG emissions.

Equipment ID	Location	MY	Model	EV Savings
1939	MOC	2015	Chevrolet Tahoe	$56,742
1875	MOC	2015	Ford F-250	$33,268
1934	MOC	2015	Chevrolet Tahoe	$30,435
1981	MOC	2015	Chevrolet Tahoe	$25,482
1935	MOC	2015	Chevrolet Tahoe	$22,242
1876	MOC	2015	Ford F-250	$21,434
1943	MOC	2015	Ford F-250	$20,888
1940	MOC	2015	Chevrolet Tahoe	$11,267
1874	MOC	2015	Ford F-250	$10,968

Figure 15 *Equipment model and EV savings*

Editor's Note

The Ford F-150 Lightning is a common EV replacement for trucks or other light-duty vehicles. However, when considering replacement for Ford F-250s or other larger trucks that have specialized parts or bodies, the Ford F-150 Lightning may not be a viable option for immediate EV replacement. Thus, communities should keep the variety of types and models of similar vehicles in mind when planning for fleet electrification.

Year 3-5

- Additionally, the recommended next wave of roll-outs can happen within two–three years and include at least 18 vehicles.
- In two years, all of these vehicles will be at the end of their lifecycle, if not past it. There are 14 Ford F-250s in this group (IDs 1194, 1195, 1720, 1724, 1783, 1759, 1858, 1859, 1871, 1875, 1876, 1943, 1874, and 1944) that should be replaced with a Ford F-150 Lightning.
- The F-150 Lightning is a feasible option considering its max payload of 2,000 lbs, range of up to 230 miles, and price of $55,150.
- Fuel costs are high for the F-250s, so compared with an F-250 XLT replacement, the F-150 Lightnings would result in total savings of $177,951 and GHG emission savings of over 56,000 kg/year.
- Within this time frame, it is recommended to replace a Dodge Charger (ID 1838), Ford Fusion (ID 1855), and two Ford Tauruses (IDs 1995 and 1915) with a Chevy Bolt.
- These four vehicles are not driven as much as others, with an average of just over 8,000 miles annually, so a Chevy Bolt should be able to satisfy driving needs. The Bolt is $25,600 and carries a range of up to 259 miles on a full charge.
- Compared to replacing these vehicles with a Chevrolet Malibu, total savings from these replacements are projected to be $4,834, while GHG emission savings are projected to be 3,600 kg/year.

Mid to Far Year Scenario

As for the future roll-out scenario of chargers, it is recommended to place the chargers near the southern edge of Sun City, near major intersections of roads, and large gathering areas such as Lake Pleasant. Based on the location of the charging stations, it may need to be a different type of charging station.

Further in the Mid-to-Far-Year, replacing the sedans and light-duty trucks is recommended first. These classes will have the highest EV savings on average, and some of the greatest GHG emission savings will come from replacing the light-duty trucks. Aiming to replace roughly 15 vehicles annually with an EV is a recommended goal. At this rate, the fleet would be electrified within 30–35 years, a manageable time-frame.

Summary of Recommendations	
Near Future Scenario (approx. 10 years)	
Set a goal of electrifying 15% of the City's total fleet, breaking down to eight new EVs per fiscal year.	Install 50 Level 2 chargers in areas with the most EV activity.
Mid-Future Scenario (approx. 30 years)	
Set a goal of electrifying 40-50% of the City's total fleet, coinciding with the expected trend of battery costs declining and EV options increasing.	Install 150 total Level 2 chargers, three Solar Arc Stations, and two Level 3 high-capacity chargers. These should be placed on critical infrastructure points as the need for more chargers in urban areas decreases.
Far Future Scenario (approx. 50 years)	
Set a goal of electrifying 100% of the City's total fleet, with the expectation that markets will stabilize and pricing will decrease with supply.	Install 300 total Level 2 chargers, 10 Solar Arc Stations, and eight Level 3 high-capacity chargers. These should fill the gaps between the critical infrastructure points, and the Level 3 chargers should be mainly placed close to high volumes of traffic.

Figure 16 *Summary timeline of student recommendations*

CONCLUSION

The most critical finding from the research and analysis revolving around the transition to electrify the City of Peoria's fleet fully was the proposed roll-out timetable in three phases. This timetable outlines the recommended method in which the City of Peoria could start transitioning its fossil fuel-dependent vehicles to EVs. This includes the benchmark 15% EV transition by 2033 and proposes the recommended amount of EV charging infrastructure to support the EV transition.

This information is essential to the City of Peoria as it provides options for officials and decision-makers to consider the most effective, affordable, and efficient methods in which the City could build more sustainable infrastructure. By using the specified roll-out timetable, the City will be able to meet their recommended EV transition goals by only replacing eight fossil fuel vehicles per year.

Looking to the future, the main factors the City of Peoria should be tracking as the EV industry evolves would be electricity demand, resource availability, and market competitiveness. As the City of Peoria transitions to EVs, it will increase its electricity consumption, so by tracking the trends of its electricity usage, it will be able to generate plans to institute more Solar Arc chargers or to reduce energy consumption in another manner. Resource availability will impact maintenance costs and the ability to purchase new vehicles; thus, by tracking these resource trends, the City maybe able to plan to purchase vehicles and parts at more affordable prices. The last trend that the City of Peoria should track would be the upfront cost-competitiveness of suitable electric vehicles. Currently, the most competitive EV market would be sedans and vans, making their cost significantly lower and the quality of their product higher. The City should be tracking these trends as it will help signify distinct times in which it would be beneficial for the transition of job-specific vehicles to their EV counterparts. With these factors and trends in mind, the City should also integrate acquisition and maintenance costs into decision-making around fleet electrification. By electrifying its fleet, the City of Peoria will be able to effectively and efficiently transition to a greener infrastructure and advance municipal sustainability goals while ensuring a greater quality of life for the community.

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