

Internal Decarbonization Plan Final Report



CITY OF LOUISVILLE

LOUISVILLE, COLORADO
OCTOBER 4, 2023



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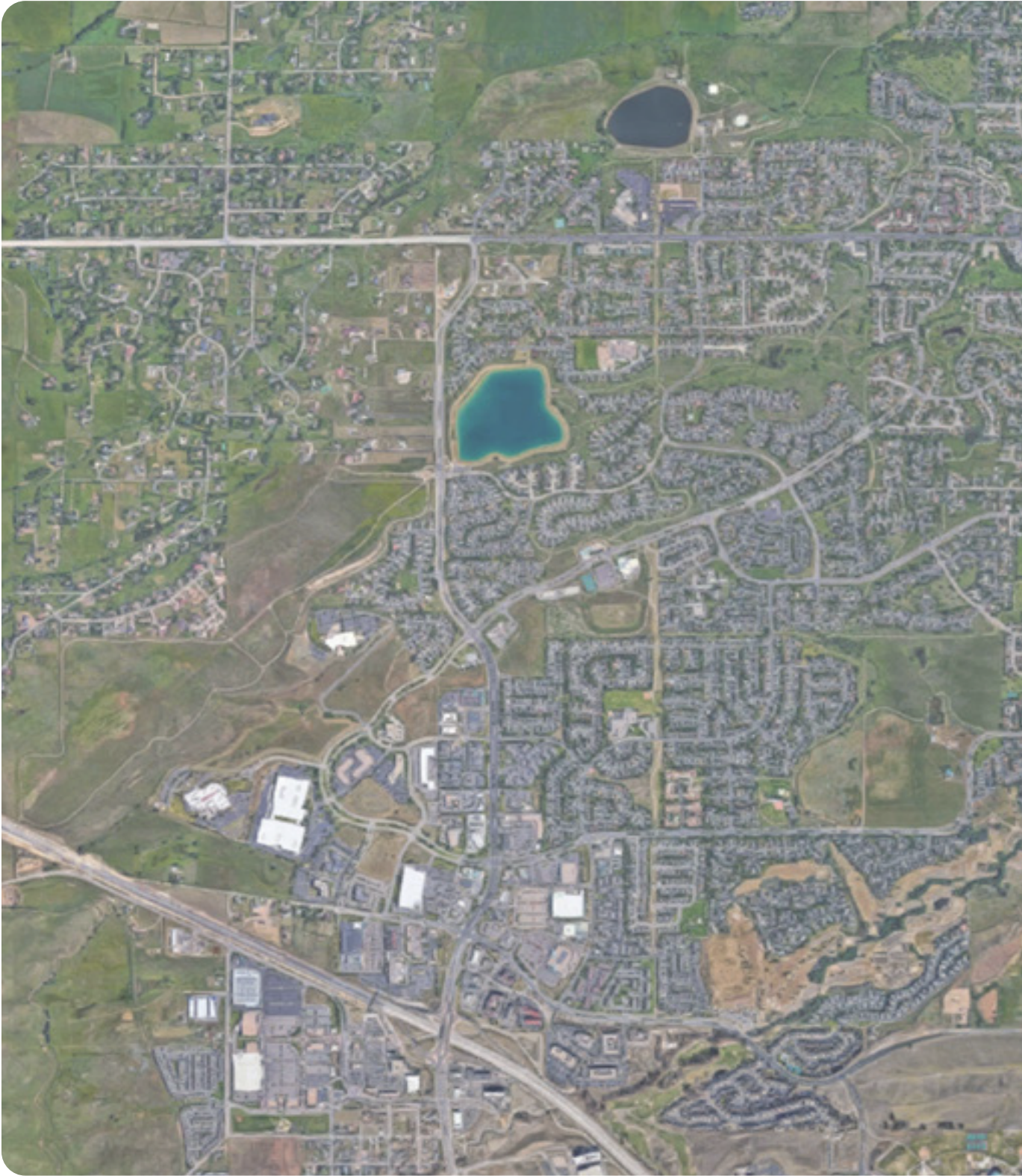
APPENDIX

Date	Version History
8/8/2023	Final Report Issued
9/19/2023	V2 - Revision
10/4/2023	V3 - Revision

Table of Contents Abbreviations

Abbreviation	Definition
AHU	Air Handling Unit
ASHP	Air Source Heat Pump
AWHP	Air to Water Heat Pump
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
CHW	Chilled Water
DHW	Domestic Hot Water
dT or DeltaT	Temperature Difference
ERV	Energy Recover Ventilator
EUI	Energy Use Intensity
EV	Electric Vehicle
FCA	Facility Condition Assessment
GC	General Contractor
GSHP	Ground Source Heat Pump
HHW	Heating Hot Water
HPWH	Heat Pump Water Heater
HVAC	Heating Ventilation Air Conditioning
IRA	Inflation Reduction Act
ITC	Investment Tax Credit

Abbreviation	Definition
kVA	Kilovolt-Ampere
kW	Kilowatt
kWh	Kilowatt-Hour
kWp	Kilowatt Peak
LED	Light Emitting Diode
MAU	Makeup Air Unit
MW	Mega Watt
NDHU	Natatorium Dehumidification Unit
PV	Photovoltaic
RCx	Retro Commissioning
ROM	Rough-Order-of-Magnitude
RTU	Rooftop Unit
SCC	Social Cost of Carbon
SHW	Service Hot Water
VAV	Variable Air Volume
VRF	Variable Refrigerant Flow
WWHP	Water to Water Heat Pump



Executive Summary | Background

Background

In August of 2019, City Council passed Resolution 25, Series 2019, which set clean energy and carbon emission reduction goals for the municipality and larger community, including:

- **Meeting 100% of Louisville’s municipal electric needs with 100% carbon-free sources by 2025**
- **Reducing core municipal greenhouse gas emissions annually below the 2016 baseline through 2025.**

The City of Louisville also adopted Resolution 25-2019 (Setting Clean Energy and Carbon Emission Reduction Goals), and a Sustainability Action Plan (adopted in October 6, 2020). On December 30, 2021, the massive Marshall Fire raged in portions of the Front Range, destroying 550 homes and businesses in Louisville alone. Climate change, which much of the fire is attributed to, became very real to the City, which had already been establishing decarbonization targets. The fire accelerated the City’s sense of urgency to act to eliminate its own carbon footprint.

In response to this urgency, in summer and fall 2022, the City contracted for the creation of a study, analysis, and strategic roadmap for electrification and decarbonization of 100% of City buildings, fleet, equipment and operations* by 2030 (as part of this study, an alternative completion target was determined). **This document is the outcome of that effort.**

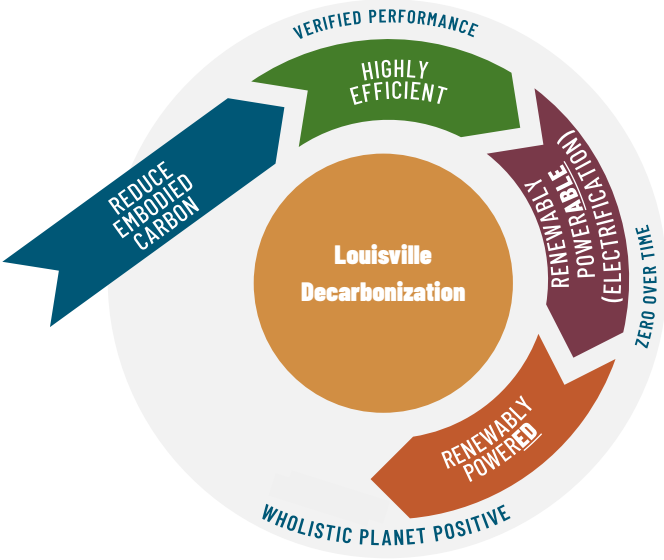
Environmental, Community, and Financial Stewardship and Leadership

Louisville is already aggressively pursuing a path to decarbonization of its own operations through efficiency and renewable electricity. This roadmap establishes a pathway to complete decarbonization, including: additional efficiency measures, renewables, and electrification of buildings, vehicles, and miscellaneous equipment. Louisville will be one of the first jurisdictions in the United States to aggressively embark on decarbonized operations. By taking responsibility for its carbon and climate impacts, Louisville is an exemplar to its own residents as well as the broader world. On a more focused level, the specific efforts Louisville is taking provide a “show and tell” opportunity for decarbonization through communications to City residents and beyond.

**Note this roadmap does not include decarbonization for water and wastewater process loads, purchasing, solid waste/recycling/composting, or street lighting. It also does not include equipment that is used via third-party contracts.*

What is Involved in Decarbonization

What is decarbonization? It is the process of eliminating all activities that generate CO2 and other greenhouse gases (in aggregate, known as CO2e -equivalent). Today, the city’s operations (buildings, fleet, miscellaneous equipment) generate 3,400 metric tons of CO2e annually, which is equivalent to the carbon generated by 430 homes in a year.



Eliminating Louisville’s carbon footprint requires focus on four main areas:

Embodied Carbon Retrofitting existing buildings, rather than tearing down and building new zero carbon buildings, reduces the carbon inherent in the construction process.

Efficiency & Load Reduction Reducing building energy use, and thereby reducing carbon emissions, reduces the amount of renewable energy needed for total decarbonization.

Renewably Powerable Reducing on-site fossil fuel burning via electrification allows the building to be powered by renewable sources.

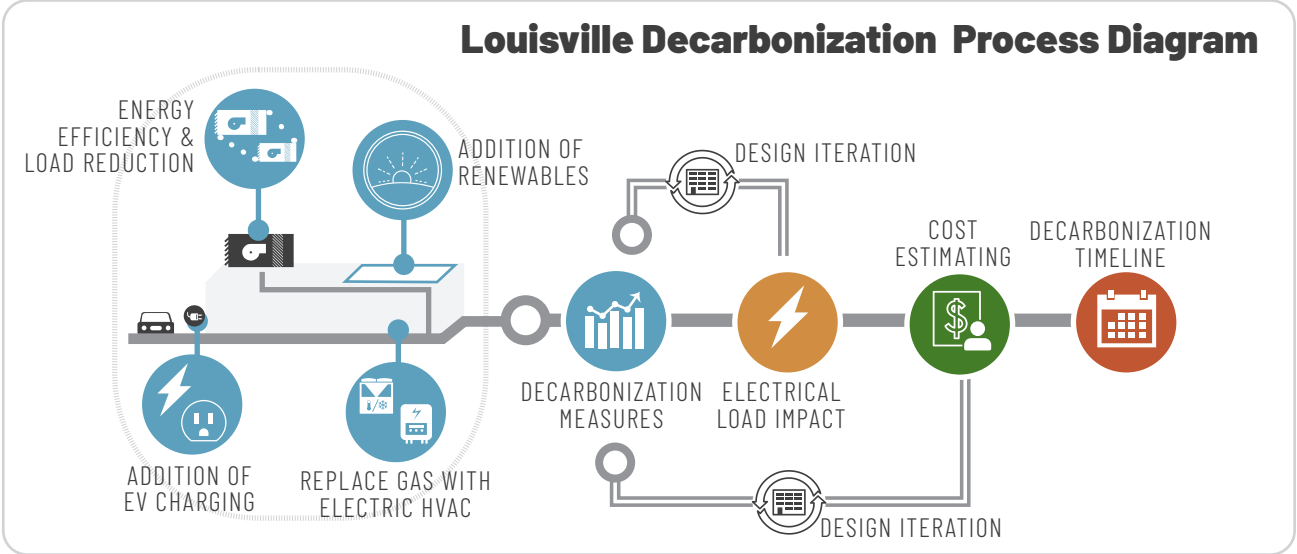
Renewably Powered Optimizing the mix of available renewable zero-carbon sources leads to decarbonization at the best value for the City of Louisville.

Note that these activities aren’t necessarily implemented sequentially – this plan identifies the most cost-effective and high-value phasing plan for implementation .

Core Principles

There are a number of big picture principles and concepts that further illuminate this plan:

- Be fiscally responsible and avoid replacing equipment before it is worn out.** Allocate the replacement budget to the decarbonized alternative instead, which will typically save 25-50% of the capital cost. Also work within the context of existing equipment and reuse existing systems wherever possible. Completely tearing out and replacing systems has higher embodied carbon, is usually more costly, and always more disruptive.
- Use proven technologies.** Full zero carbon performance can be achieved via current technologies. Louisville needs results and should not be a guinea pig for untested technologies.
- Provide the greatest value for least cost.** Full decarbonization, particularly electrification, is expensive. It is critical to pursue the various financial incentives available at the local, state, and federal level. In addition, many decarbonization measures can provide co-benefits, providing value streams that offset costs.
- Zero carbon power.** Louisville acquires 100% renewable electricity through utility purchase programs, so all electrical uses are assumed to emit zero carbon. However, reducing energy and electrical load has other financial benefits and related co-benefits.



Key Findings

Clear, full, decarbonization pathways exist for all City buildings and its fleet. In most cases these approaches are based on retrofitting the existing HVAC systems, not gutting the building entirely.

Efficiency and load reduction strategies often have lower life-cycle costs than current electricity costs. These are outlined in greater detail in the individual building reports and are recommended for immediate implementation.

Hybrid building electrification is an excellent near and mid-term approach. Hybrid mechanical heating systems, which utilize electricity as the primary heating source and natural gas as a backup, achieve the decarbonization “sweet spot” via substantial carbon reductions (i.e. 75%+) while reducing overall costs up to 50%.

City-owned renewable electricity generation will reduce utility costs and provide greater benefit to the Louisville community. Substantial opportunities exist for on-site renewable electricity. A combination of Inflation Reduction Act and Xcel Energy incentives make this a very attractive option for the City and result in on-site renewable electricity being cheaper than utility-provided electricity. In addition, on-site renewables provide additional resiliency and signal the City’s commitment to decarbonization

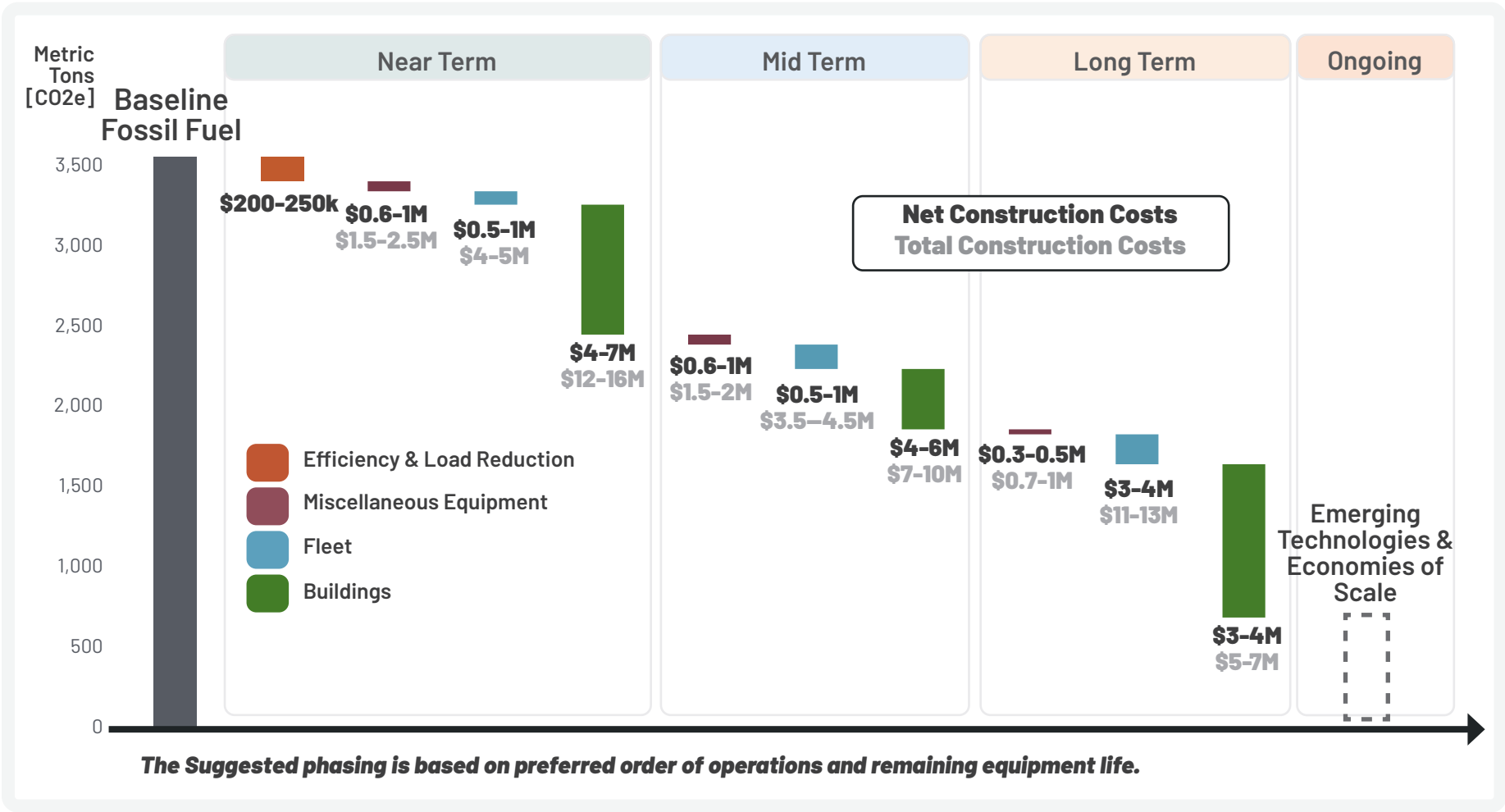
Key Recommendations

Based on the findings above and detailed findings throughout this report, a formal adoption of the City’s decarbonization target is recommended:

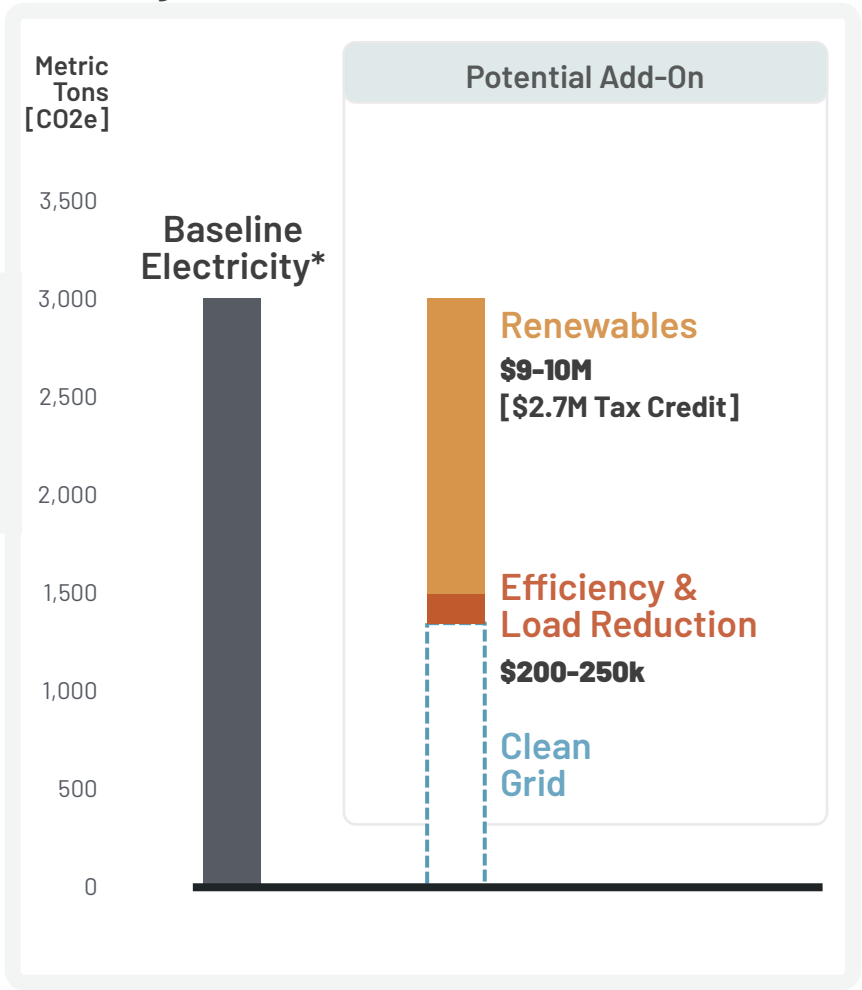
- 100% Decarbonization by 2040**
- Retain 100% Renewable Electricity** (underway)
- Decarbonization Plan Progress Update Every 5-7 Years**

Executive Summary | Decarbonization Implementation Plan

Fossil Fuel Emissions



Electricity Emissions



Efficiency & Load Reduction & Renewables reduce electricity that would need to be offset by nearly **50%**.

Emerging technologies & economies of scale will help bring Louisville to **Zero Carbon** emissions.

Cost Summary Table	
Total Construction Costs	~\$51M
Total Like-for-Like Construction Costs (costs that the City would continue to pay)	(~\$27M)
Lifecycle Utility Cost Savings (Utility, Fleet, Solar)	(\$7M)
Total Grants	(\$3M-13M)
Total Net Cost of Decarbonization (varies based on final grant awards)	\$4M-14M

Notes:

Total Construction Costs: Total **turnkey** construction costs needed for budgetary purposes. Costs do not include incentives or grants. The Inflation Reduction Act will potentially offset 30-40% of the cost of renewables and fleet.

Total Like-for-Like Construction Costs: The **turnkey** “business as usual” costs for replacing existing fossil fuel equipment with similar fossil fuel equipment. Costs were derived from a combination of the City’s CIP budget and detailed cost estimating of equipment replacement as the comparison scenario.

Net Construction Costs: (Total Construction Costs) - (Total Like-for-Like Construction Costs)

Total Net Cost of Decarbonization: (Total Construction Costs) - (Total Like-for-Like Construction Costs) - (Total Project Savings + Total Grants)

Turnkey Costs: Include design, engineering, construction management, project management, and commissioning.

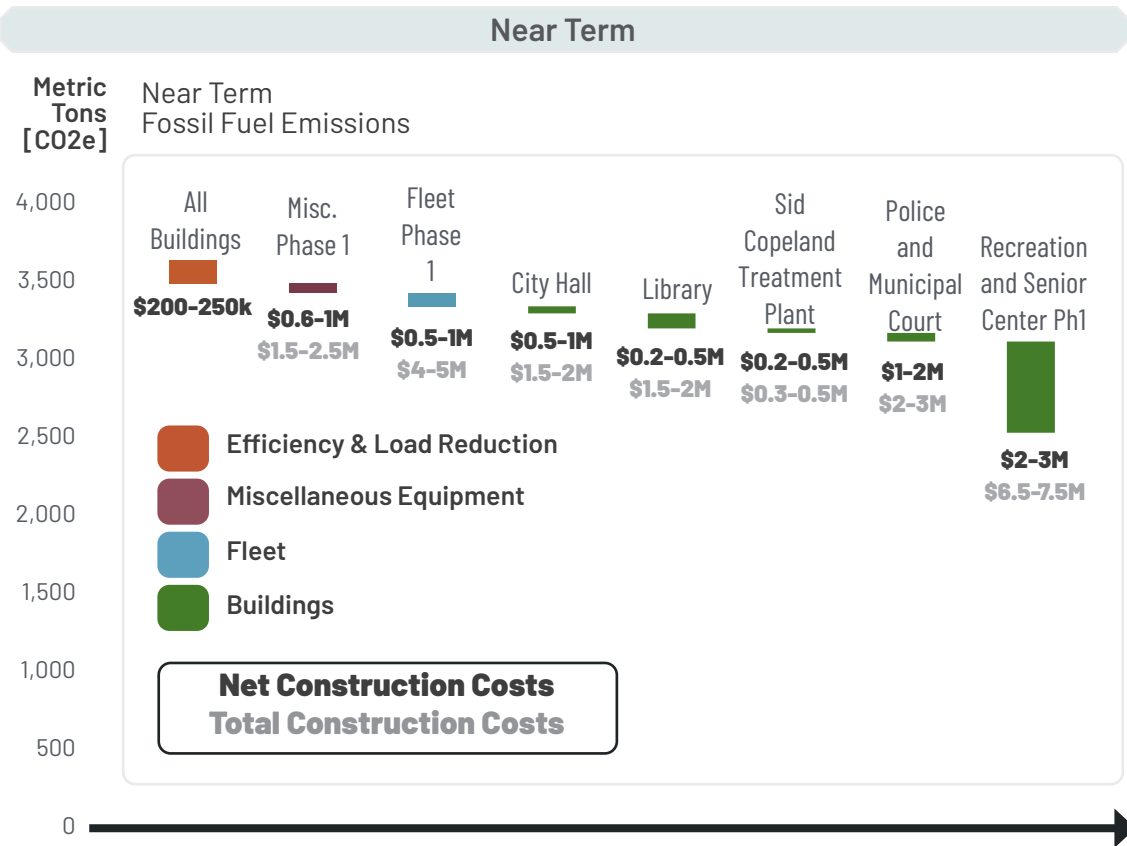
Building costs include costs associated with EV charging (chargers and electrical infrastructure upgrades)

*Assumes 2023 Xcel Grid Mix

Savings Summary by Measure		Life Cycle Carbon Reduced	Baseline Carbon % Reduction	Baseline Electricity Offset
	Building Hybrid Electrification	34,000 tonnes	60%	-
	Fleet Electrification	6,500 tonnes	12%	-
	Miscellaneous Electrification	2,500 tonnes	4%	-
	Efficiency & Load Reduction	2,400 tonnes	4%	5%
	Renewables	-	-	45%
Total		45,400 tonnes	82%	50%

Decarbonization Implementation Plan | Near Term Plan

Near Term Roadmap



Near Term Projects

Efficiency & Load Reduction

All Buildings

Renewables

(2.5) MW
(8) Sites

Evaluate Xcel renewable purchase needed for 100% offset after installation.

Miscellaneous Electrification

Replace ~40% of remaining gas equipment

Fleet Electrification

(62) Vehicles
(36) ICE - Internal Combustion*
(26) EV - Electric Vehicle

**Part of the fleet, including police vehicles, do not currently have a viable EV replacement that will be market-ready before the existing vehicles need replacement. Therefore, some ICE's are still necessary for the initial phases of this plan.*

See the appendices of the building audit reports for detailed descriptions of scope for each decarbonization measure.

Building Hybrid Electrification & EV Charging

City Hall

(2) Heat Pump RTUs
(17) VAVs
(1) ERV + ASHP
(7) EV Chargers

Library

(3) Heat Pump RTUs
(1) Electric DHW
(9) EV Chargers

Sid Copeland Water Treatment

(1) Heat Pump RTUs
(7) Electric Unit Heaters
(3) EV Chargers

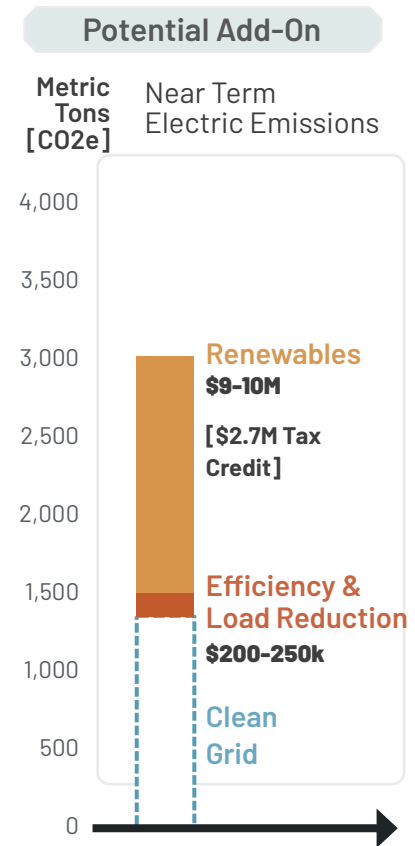
Police & Municipal Court

(3) Heat Pump RTUs
(7) Electric Unit Heaters
(6) EV Chargers

Recreation & Senior Center Ph1

(13) Heat Pump RTUs
(1) Pool NDHU
(5) EV Chargers

Add-On



Near Term Implementation Notes

Renewable Phasing

Renewables are recommended to be implemented right away to take advantage of existing federal and state funding options.

Efficiency & Load Reduction Phasing

Efficiency & load reduction measures are recommended to be implemented right away to realize any potential downsizing for mechanical and electrical systems as buildings are upgraded in the future.

Recreation Center Phasing

The Recreation & Senior Center measures are split into two phases. The first phase addresses the majority of the RTUs that are near end-of-life and one of the pool natatorium dehumidification units (NDHUs).

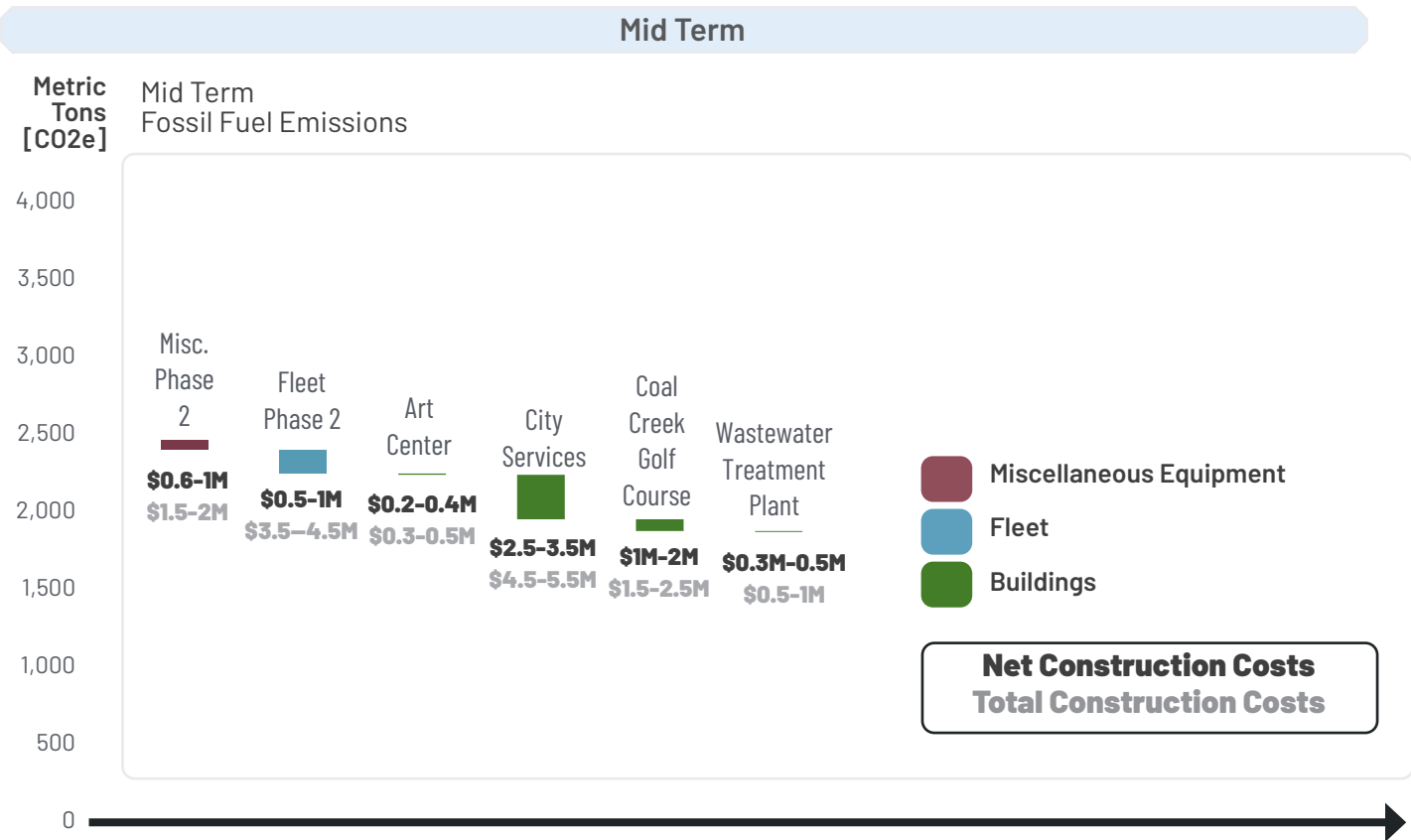
Near Term Summary Table

		Life Cycle Carbon Reduced [tonnes]	Total Construction Costs*	Total Like-for-Like Construction Costs*	Net Construction Costs*
	Building Hybrid Electrification	13,000	\$12-16M	\$8.1-9M	\$3.9-7M
	Fleet Electrification	1,300	\$4-5M	\$3.5-4M	\$0.5-1M
	Miscellaneous Electrification	1,000	\$1.5-2.5M	\$0.9-1.5M	\$0.6-1M
	Efficiency & Load Reduction	2,400	\$0.4-0.5M	-	\$0.4-0.5M
	Renewables	-	\$9-10M	-	\$9-10M
Total		17,700	\$27-34M	\$13-15M	\$14-20M

*Costs do not include incentives or grants. The Inflation Reduction Act will potentially offset 30-40% of the cost of renewables and fleet.

Decarbonization Implementation Plan | Mid Term Plan

Mid Term Roadmap



Mid Term Implementation Notes

City Services

Significant upgrades occur at the City Services building where both major building electrification upgrades and EV Charging upgrades are proposed. EV charging scope at City Services is the largest as it will be the home to the majority of the city's fleet.

Mid Term Projects

Building Hybrid Electrification & EV Charging

Coal Creek Golf Course

- (1) Heat Pump RTUs
- (2) ERV + ASHP
- Kitchen Electrification
- (4) Electric Unit Heaters
- (3) EV Chargers

Art Center

- (1) ERV + ASHP

Wastewater Treatment Plant

- (1) ASHP
- (1) Electric Unit Heaters
- (1) Electric DHW
- (2) EV Chargers

City Services

- (1) ERV + WC VRF System
- (1) AHU Coil Retrofit
- (1) Hydronic AWHP
- (1) Electric Hotsy Washer
- (~50) Electric Unit Heaters
- (1) Electric DHW
- (28) EV Chargers

Fleet Electrification

- (35) Vehicles
- (11) ICE - Internal Combustion
- (24) EV - Electric Vehicle

Miscellaneous Electrification

Replace ~40% of remaining gas equipment

See the appendices of the building audit reports for detailed descriptions of scope for each decarbonization measure.

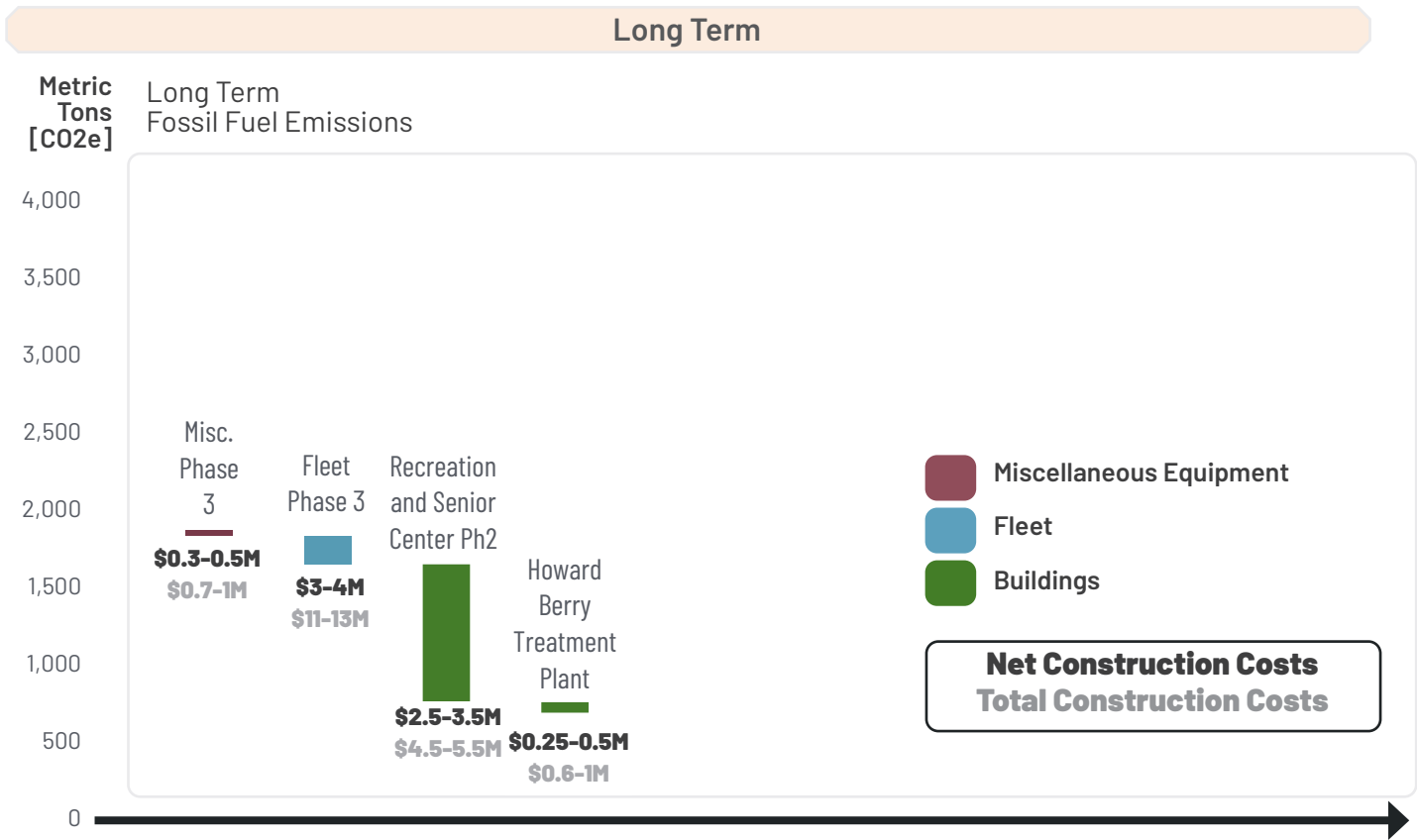
Mid Term Summary Table

		Life Cycle Carbon Reduced [tonnes]	Total Construction Costs*	Total Like-for-Like Construction Costs*	Net Construction Costs*
Measures					
	Building Hybrid Electrification	6,000	\$6.8-10.1M	\$2.8-3.7M	\$4-6.4M
	Fleet Electrification	2,400	\$3.5-4.5M	\$3-3.5M	\$0.5-1M
	Miscellaneous Electrification	1,000	\$1.5-2M	\$0.9-1M	\$0.6-1M
	Efficiency & Load Reduction	-	-	-	-
	Renewables	-	-	-	-
Total		9,400	\$12-17M	\$7-8M	\$5-8M

*Costs do not include incentives or grants. The Inflation Reduction Act will potentially offset 30-40% of the cost of renewables and fleet.

Decarbonization Implementation Plan | Long Term Plan

Long Term Roadmap



Long Term Implementation Notes

Recreation & Senior Center

The remaining Recreation & Senior Center upgrades are completed during this phase. Note that the remaining gas RTUs are not electrified due to existing electrical capacity. Re-evaluate existing electrical capacity at the time of this study to see if additional RTUs can be electrified.

Long Term Projects

Building Hybrid Electrification & EV Charging

Howard Berry Treatment Plant

- (1) Electric MAU
- (2) Electric Unit Heaters

Recreation & Senior Center Ph2

- (1) Pool NDHU
- (6) Pool Heat Pump Water Heaters
- (1) DHW Heat Pump

Fleet Electrification

- (116) vehicles
- (1) ICE - Internal Combustion
- (115) EV - Electric Vehicle
- (68) 2031-2035
- (48) 2036-2040

Miscellaneous Electrification

Replace ~20% of remaining gas equipment

See the appendices of the building audit reports for detailed descriptions of scope for each decarbonization measure.

Long Term Summary Table

		Life Cycle Carbon Reduced [tonnes]	Total Construction Costs*	Total Like-for-Like Construction Costs*	Net Construction Costs*
Measures					
	Building Hybrid Electrification	15,000	\$5-7M	\$2.3-3M	\$2.8-4M
	Fleet Electrification	3,000	\$11-13M	\$8.5-9M	\$2.5-4M
	Miscellaneous Electrification	500	\$0.7-1M	\$0.4-0.5M	\$0.3-0.5M
	Efficiency & Load Reduction	-	-	-	-
	Renewables	-	-	-	-
Total		18,500	\$17-21M	\$11-13M	\$6-9M

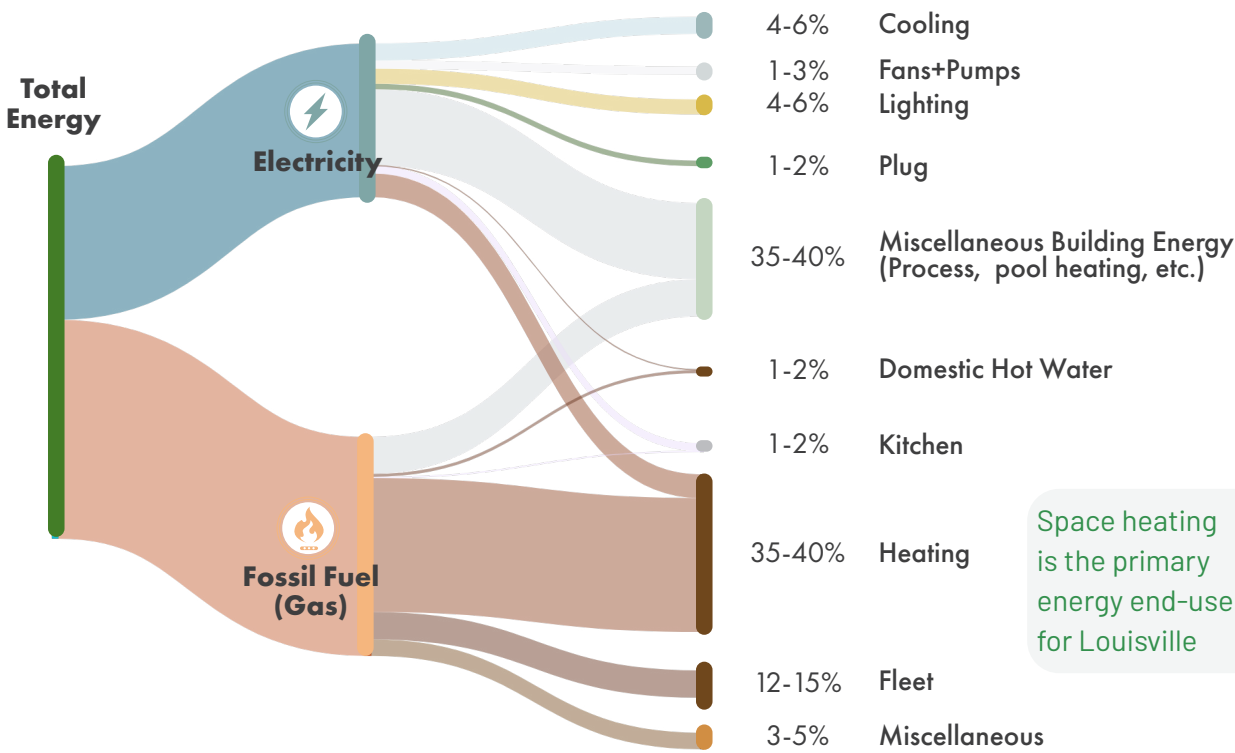
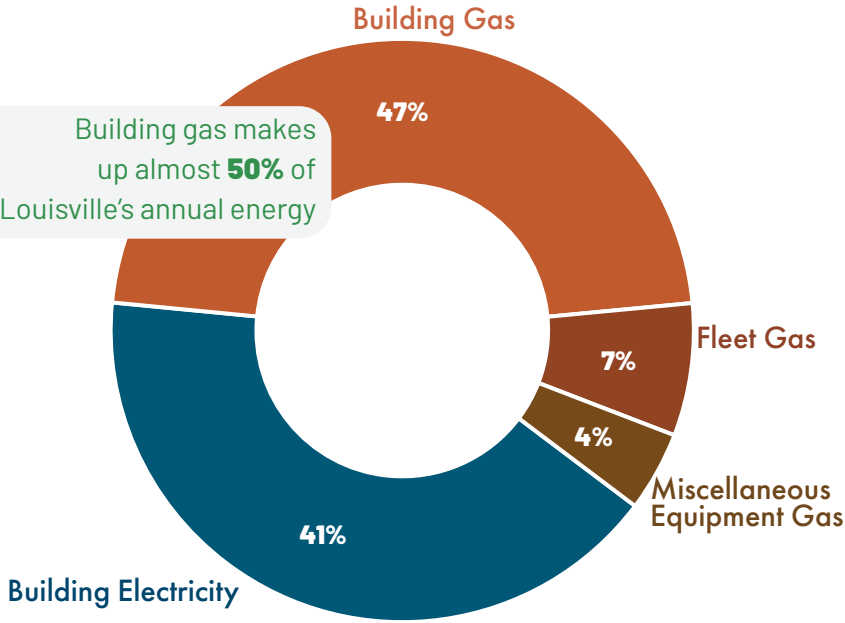
*Costs do not include incentives or grants. The Inflation Reduction Act will potentially offset 30-40% of the cost of renewables and fleet.

Energy vs Carbon

Energy use and carbon emissions are sometimes used interchangeably, but they are quite different. Carbon emissions come from burning fossil fuels – those burnt fossil fuels provide energy to buildings. Energy can also be provided to buildings via zero-carbon sources, such as renewables.

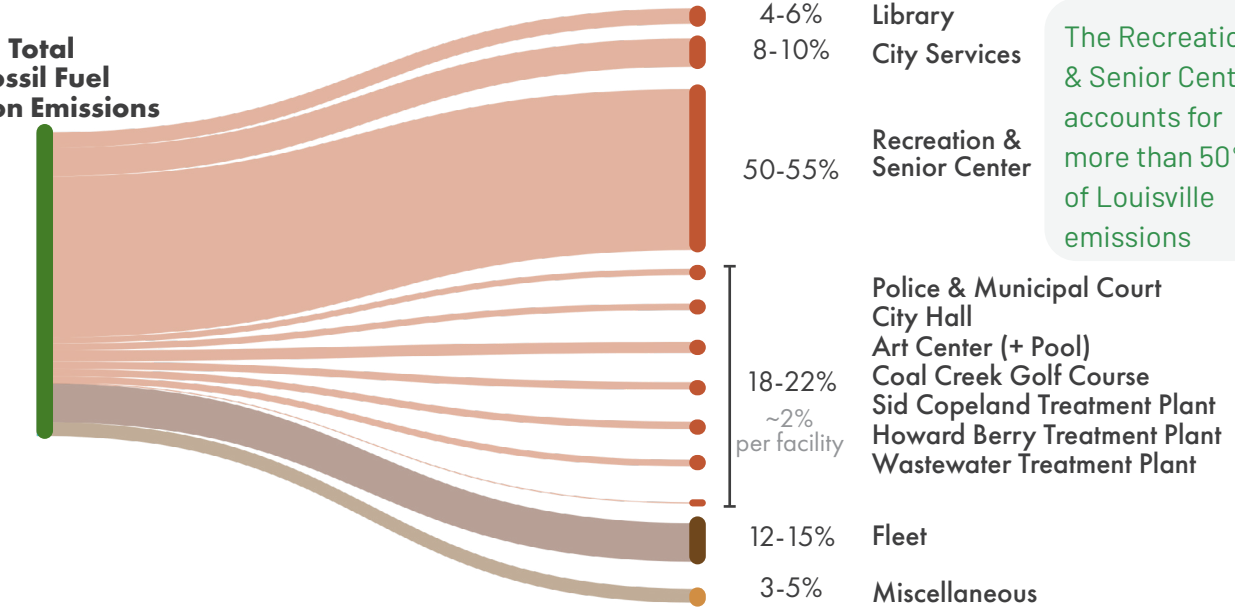
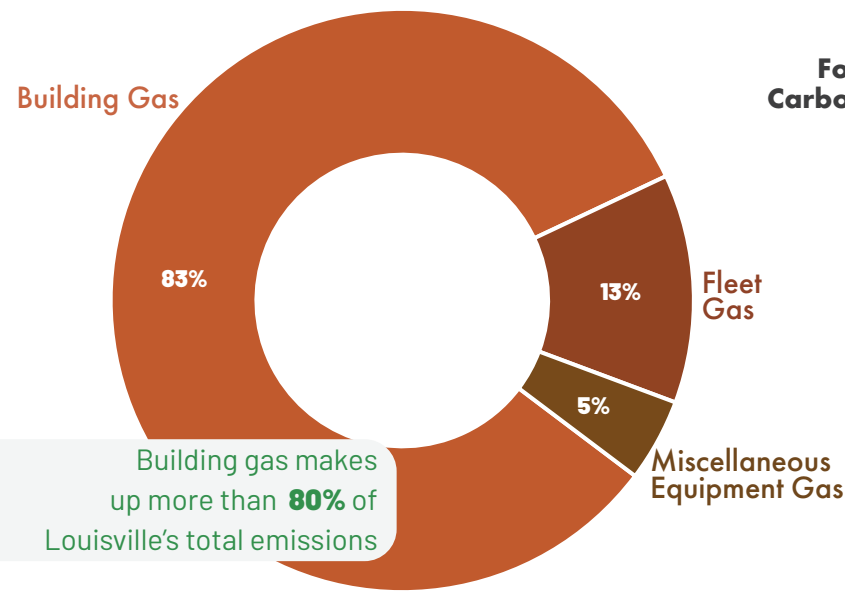
The City of Louisville participates in programs to offset their existing electrical consumption with renewable sources. **Therefore, for the purposes of this study the total carbon emissions at Louisville will be solely driven by on-site fossil fuel combustion and emissions associated with electric consumption will be zero.**

Energy End-Use



Space heating is the primary energy end-use for Louisville

Fossil Fuel Carbon Emission End-Use



The Recreation & Senior Center accounts for more than 50% of Louisville emissions

Decarbonization Implementation Plan | Zero Carbon Electricity

Cost of Zero Carbon Electricity

The City’s decarbonization approach is predicated on 100% renewable electricity. Given this, the question becomes, **what is the best source of renewable power for the Louisville’s operations?**

The table to the right summarizes the cost of zero carbon electricity. **Based on this assessment, acquisition of renewable electricity over time is recommended to follow the following prioritization:**

- **Decrease electrical demand through efficiency & load reduction.**
- **On-site renewables**
- **Renewable percentage inherent in standard Xcel electricity over time**
- **Xcel windsource**

Based on this hierarchy, and given the City’s current use of Xcel standard and Windsource electricity, this plan identifies the best opportunities for efficiency and on-site renewables for the City.



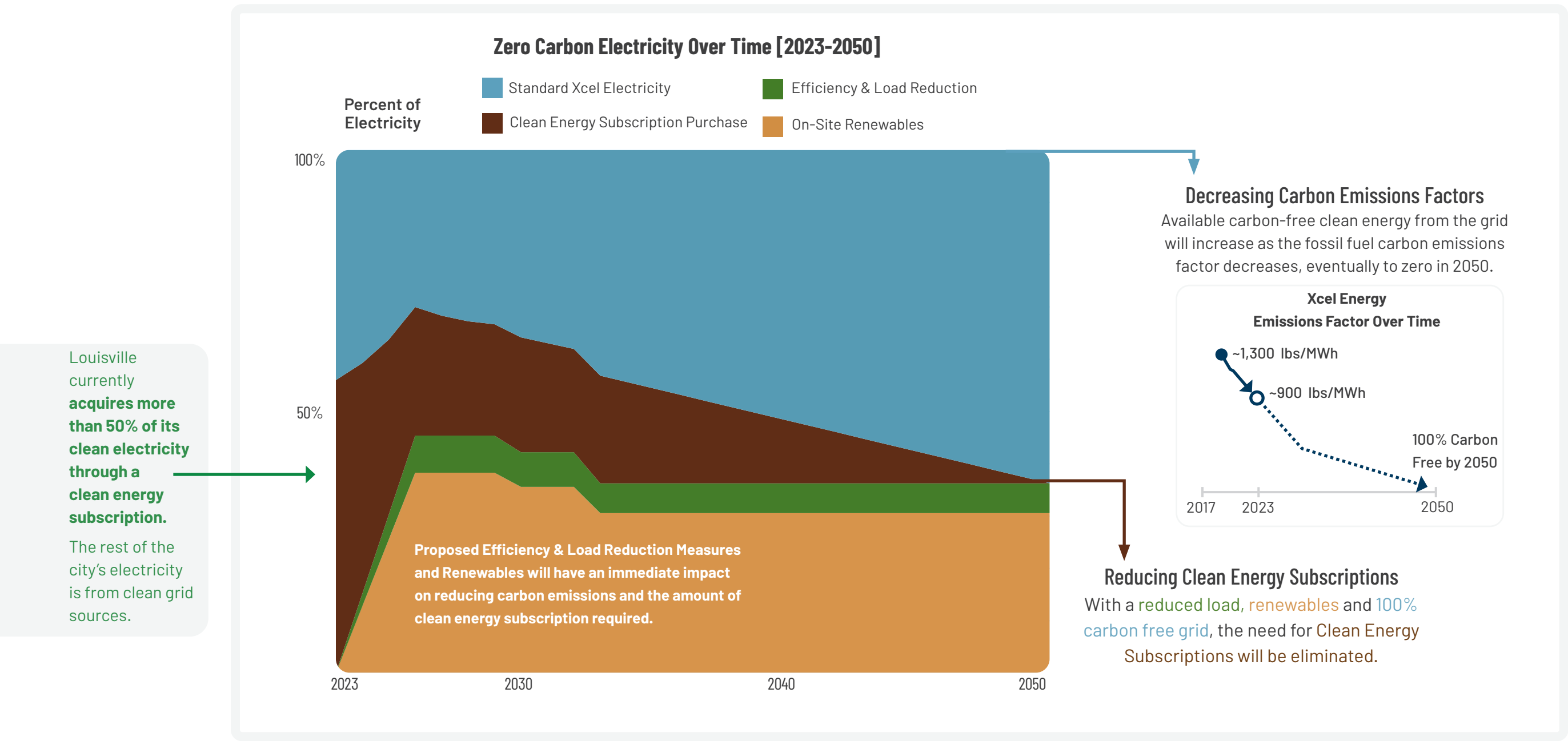
Type	\$/kWh	Pros	Cons
Efficiency & Load Reduction	0.04 \$ / kWh	• Reduces islanded electricity demand during power outages • Sometimes includes co-benefits • Avoids line loss of utility scale solar • Avoids solar/wind impacts of utility scale renewables	• Some facility disruption; contracting time/process
On-site Renewables	0.065 \$ / kWh (assumes 25.5% IRA direct payment)	• Demonstrate decarbonization to local Louisville community and encourage others to do same • Avoid solar sprawl at scale - avoiding impacts to rural areas • Enable immediate accrual of energy benefits • 25% of cost incentive available through Inflation Reduction Act • Production incentives available from Xcel with REC sale • Avoid electrical energy loss due to transmitting power over long distances • When on-site renewables are a small percentage of the total usage of facility – such as Louisville’s on-site opportunities - most solar electricity would be self used and thus not negatively impact grid • Enable future resiliency through addition of batteries and storage	• Requires maintenance (cost included in cost per kwh to left) • Best installed in conjunction with roof replacement, limiting time window • Can only provide portion of needed renewable electricity
Standard Xcel Electricity	0.065-0.070 \$ / kWh	• Provides some renewable electricity inherent in mix, increasing over time • More expensive than on-site solar per kwh • Ease of implementation, will occur on its own over time –no need for contracting for on-site renewable installation	• Possibility of Xcel not meeting promised renewable target/uncertainty/longer uptake • Solar and wind sprawl/impacts in rural/farming areas • Line loss/less efficient • Doesn’t support resiliency
Xcel Windsource	0.07-0.08 \$ / kWh (base rate + 0.015 \$/kWh)	• Enables immediate provision of 100% renewable electricity; not subject to allocation • Ease of implementation –no need for contracting for on-site renewable installation • Contractually guaranteed renewable source	• Most expensive source of renewables • Avian and aesthetic impacts of wind turbines • Line loss/less efficient • Doesn’t support islandability
Xcel Renewable Direct*	0.065-0.070 \$ / kWh	• Approximate cost parity with standard grid electricity • If can be obtained, enables immediate acquisition of renewable power	• Not currently available • Limited availability, subject to new renewable projects • Solar and wind sprawl/impacts in rural/farming areas • Line loss/less efficient • Doesn’t support resiliency

**Renewable Direct is only available occasionally based on subscription. There is a current waiting list to join.*

Decarbonization Implementation Plan | Zero Carbon Electricity

Zero Carbon Electricity Strategy

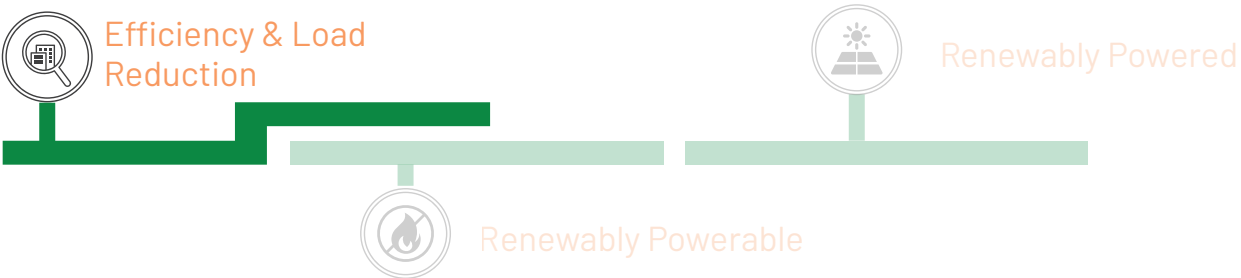
The City of Louisville will utilize a toolbox of strategies to successfully electrify and decarbonize emissions associated with on-site fossil fuel combustion. With an electric utility grid that still has fossil fuel emissions embedded, load reduction and renewables will be key in a quick carbon emissions decrease. Additionally, Xcel’s commitment to achieve a 100% carbon free grid by 2050 will play a large role in the decarbonization effects of electrification over time. Combining all these strategies will eliminate the need for Clean Energy Subscriptions over time. The following strategies support the assumption that emissions associated with electric consumption will be zero.



Efficiency | Efficiency & Load Reduction

Efficiency & Load Reduction

The recent shift towards decarbonization still operates on the core foundation of reducing building’s overall energy use. Measures can have two functions: reducing annual energy/carbon consumption and reducing peak building demand load. These measures are often incentivized by Xcel and may have shorter paybacks. Recommended measures throughout the city are summarized in the table below. See the appendices of the building audit reports for detailed descriptions of scope for each measure.



Load	Carbon	Measure	Art Center	City Hall	City Services	Coal Creek Golf Course	Library	Sid Copeland Treatment Plant	Police and Municipal Court	Recreation and Senior Center	Howard Berry Treatment Plant	Wastewater Treatment Plant
■	■	GLAZING UPGRADES Upgrade glazing units where failing/single-pane glazing still exists.	●	●						●		
□	■	HVAC OCCUPANCY SENSORS Provide occupancy sensors for HVAC setback.							●			
■	■	POOL COVER Provide pool cover for reduced evaporation losses.								●		
□	■	PUMP VFDS Provide variable speed for pumping systems.					●					
□	■	CONTROLS OPTIMIZATION / RETRO-COMMISSIONING (RCX) Optimization of existing controls sequence and operation.	●	●	●		●		●	●		
□	■	SCHEDULE SAUNA Provide temperature scheduling of Sauna during unoccupied hours.								●		
■	■	DUCT AIR SEALING/INSULATION Provide duct air sealing for leaky duct systems.					●					
■	■	ENVELOPE AIR SEALING Provide envelope air sealing for leaky buildings.	●	●	●	●	●	●	●	●		●
□	■	LIGHTING CONTROLS/VACANCY SENSORS Upgrade lighting controls for vacancy sensors.		●		●	●	●	●	●	●	●
□	■	ADVANCED PLUG LOAD REDUCTION Plug load reduction systems.		●	●	●	●		●	●		
■	■	LED LIGHTING Upgrade lighting to LED.		●				●			●	
□	■	COMPRESSED AIR LEAKS Provide commissioning to compressed air system to resolve any leaks.			●	●						
■	■	ENVELOPE INSULATION Provide envelope insulation upgrades where no-insulation or poor insulation exists.				●						

Why Are We Electrifying?

A powerful tool towards decarbonization is “electrification”, which has become a big movement not just in the construction industry, but also in most industries of our society. There are a few driving principles behind this movement:

- 

Electricity is currently produced using a range of sources:

 - Carbon emitting fossil fuels – natural gas, coal, oil
 - Zero-carbon sources – hydro-power, nuclear, wind, solar, etc.
- 

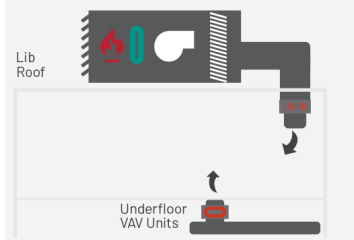
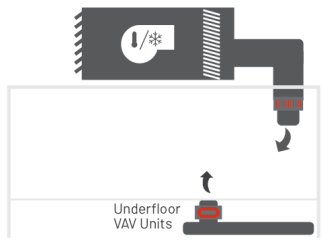
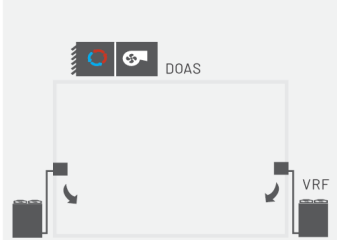
Natural gas inherently emits carbon when burned, meaning gas-based heating sources will always emit carbon
- 

The power grid is shifting away from fossil fuels and towards zero-carbon sources, due to a variety of factors including economic, regulatory, and societal
- 

Electrifying our heating systems means their carbon emissions will drop as the grid continues to add more renewables, eventually dropping to zero

The first step for electrifying space and water heating system was to evaluate various system options. Options were evaluated at each building site, where considerations like energy and carbon savings, incremental cost impact, complexity of design, and additional other factors were all considered when making a recommendation. **Please see the individual building audit reports for additional detail.**

HVAC System Matrix Example

Existing System	Recommendation	High Performance Retrofit Alternate
VAV hot water reheat	Packaged heat pumps and electric boiler	DOAS with ACVRF throughout – full system replacement
		

Full Electrification vs Hybrid Electrification: Space & Water Heating Systems

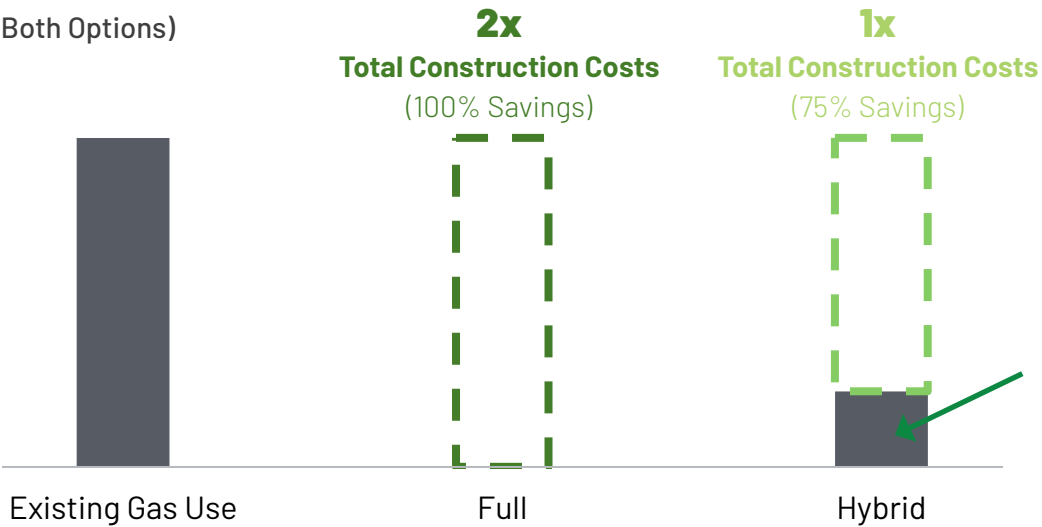
Heating is the single largest source of carbon emissions by Louisville, through burning of natural gas in boilers and furnaces. Heat pumps offer an incredible opportunity to both electrify and save energy, since they run on electricity and are also ~2-3x more efficient than natural gas based heating.

However, while heat pump-based heating is an excellent tool for building electrification, today’s technology still requires supplemental heating for the coldest days. In general, it can be expensive to electrify the “last 10%” peak, because the system is sized for the coldest day of the year, which rarely occurs.

Hybrid heat pump/natural gas peaking systems are a useful tool for sensible and cost-effective decarbonization, as they strike a balance between carbon reduction, construction costs, and utility demand costs. For fully electrified heating systems, that supplemental heating would be provided by electric resistance heating, which is capable of low temperature operation. However, in most facilities this approach results in two negative consequences: a costly electrical service upgrade is required, and operating expenses increase due to high peak electrical draw and resulting Xcel demand charges. In many cases, using gas as the peaking fuel source on the coldest day will mitigate need for an electrical upgrade while still achieving significant carbon reductions. The decarbonization “sweet spot” is a heat pump system that meets most of the annual heating demand, supplemented by a gas system to meet the rare coldest days. This results in substantial carbon reductions (i.e. 75%+) while reducing overall costs up to 50%. Retaining the gas supplemental heating until the next replacement cycle in the late 2030s enables:

- Potential technology evolution, such as 100% heat pump heating even on coldest days, renewable fuel cells, and/or strategic and accessible use of bio-gas for peaking boilers.
- Developments in demand shifting technology (e.g. batteries), resulting in lower demand charges.
- Changes in relative cost of natural gas vs. electricity, increasingly favoring electricity.
- Full utilization of useful life of natural gas equipment.

Full vs Hybrid Electrification
(At Sites w/ Both Options)



Hybrid solutions do not make sense at some sites due to existing electrical capacity and expected future loads. In these cases, **full electrification** is recommended.

The last 25% of gas usage is **~4x more expensive** to electrify than the first 75%.

Additional Considerations

Heating Capacity Oversizing

For the most part, electrified heating system capacities were sized similarly to the existing fossil fuel equipment. As these projects enter the detailed design phase, there is opportunity to minimize electrical impact by identifying equipment that can be downsized. This is particularly impactful in spaces that have freeze protection heating.

Structural Impacts

Some of the proposed measures have an impact on the existing building structural system. These impacts have been included in the construction costs and are detailed in the building audit reports.

Staged Mechanical Electrification

In general, Building Electrical Code requires electrical service to be sized based on nameplate power data for mechanical equipment. Thus, if all mechanical equipment is electrified at the same time, the electrical service upgrade would need to match the total nameplate power. This can lead to oversized electrical systems as mechanical systems are often oversized. For example, the Recreation & Senior Center existing nameplate load is calculated at 2,200 Amps, but utility data shows the actual demand peaking at 550 Amps.

As an alternate approach, Electrical Code also allows for the use of metering data to determine the actual power draw of the equipment; the actual data is then used to determine whether an electrical service upgrade is needed. A staged approach would install a couple electrified units and trend the new electrical load; if the power draw of the mechanical equipment is proven to be less than the nameplate, then additional load could be added to the existing service. This process would be repeated until either the service needs to be upgraded or all units are electrified.

Building Electrical System Considerations

Battery System

Use of battery systems is growing across the building industry, both for resiliency and demand reduction purposes. However, batteries are not suited for every situation. A 250 kW battery system was evaluated for the Recreation and Senior Center, mostly for demand reduction and load shifting purposes. However, the high first cost was unable to offset the annual demand cost reductions, and resulted in a payback longer than the measure life. While this option is currently not included in this plan, it could become a viable option in the future as the technology improves and becomes more cost-effective.

Backup Power

Throughout this study, the impacts to existing backup power systems were evaluated where buildings already had generators. In general, it is recommended to continue using fossil fuel-based generators (e.g. propane) instead of using batteries. Since these units very rarely run, the added cost of batteries is not justifiable. Additional information is available for each building in the building audit reports.

Net Cost of Electrification

The total cost is the total amount that will need to be allocated for budgetary purposes. The net cost represents the total cost minus the replacement cost that would’ve been spent to replace the existing units with like-for-like fossil fuel units. Note that there is a significant net cost premium for full electrification due to electrical upgrades.



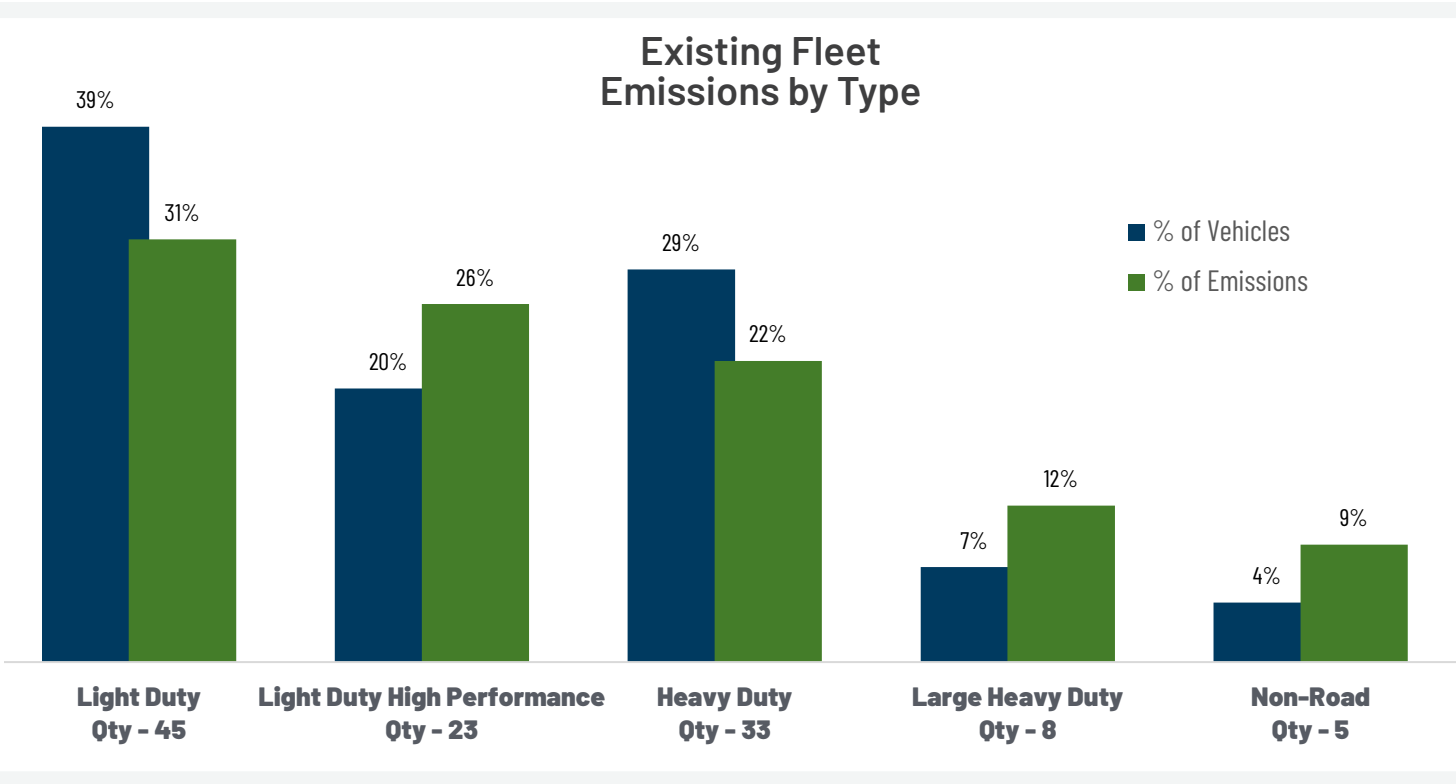
Renewably Powerable | Fleet Electrification

Existing Fleet

The City of Louisville provided data from 2022 for their fleet vehicles. Vehicles utilized by the city were divided into five categories.

- 1. **Light duty vehicles** – Light duty vehicles make up the majority of the vehicles the city owns. They typically encompass any normal passenger vehicle such as sedans, SUVs, light pickup trucks, and minivans. This vehicle is mostly used for transporting people and small amounts of cargo.
- 2. **Light duty high performance vehicles** – This category incorporates mainly police vehicles. These vehicles are similar to the light duty vehicles but have been altered for higher performance due to specific police requirements.
- 3. **Heavy duty vehicles** – Heavy duty vehicles mostly incorporate large pickup trucks. These vehicles are used for hauling and towing heavy loads.
- 4. **Large heavy duty vehicles*** – This category is for the large snow plows and street sweepers. These vehicles typically are only used seasonally and have a varying work load that is dependent on the weather.
- 5. **Non-road vehicles*** – These vehicles are typically construction type vehicles. There usage is usually measured in hours of operation instead of miles.

**There are not currently market-ready EV alternatives for these categories.*



Please refer to the appendix for additional details on fleet electrification

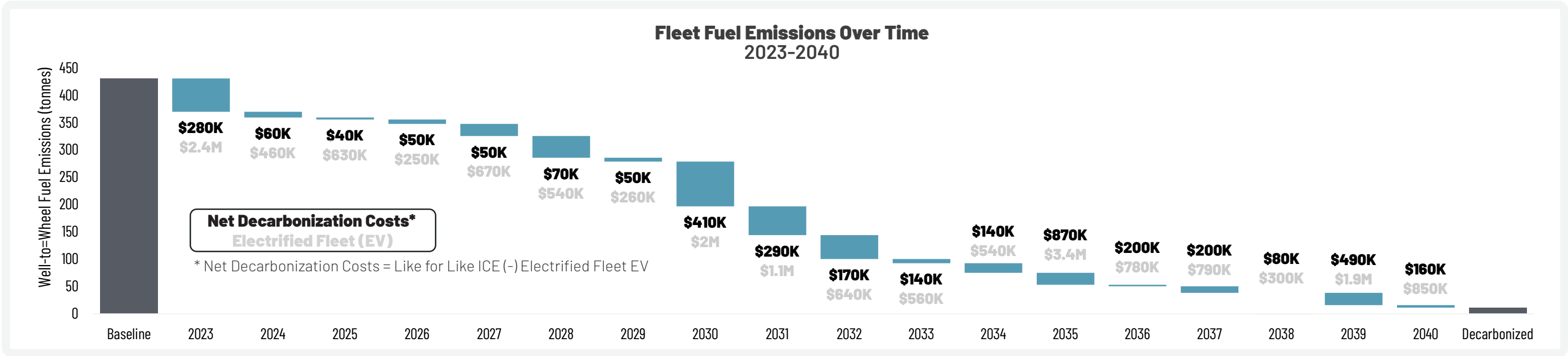
Department	Vehicle Category					Total
	1	2	3	4	5	
	Light Duty	Light Duty High Performance	Heavy Duty	Large Heavy Duty	Non-Road	
Building Inspection	3					3
Code Enforcement	2					2
Engineering	4					4
Facilities	3		1			4
Finance	2					2
Parks	10		12			22
Police	7	23				30
Rec Center	1		2			3
Streets			4	5	2	11
Utilities	2		10	2	3	17
Water Treatment	4		1			5
Waste Water Treatment	3		1			4
Open Space	4		2	1		7
Grand Total	45	23	33	8	5	114

Existing Fleet Emissions

Based on vehicle-specific annual usage, fleet emissions were calculated using publicly-available data from the Environmental Protection Agency. Three key factors contribute to a vehicle’s annual CO2 emissions: average miles driven/hours operated, fuel efficiency, and CO2 emissions factor of fuel source. Emissions data is well-to-wheel, meaning it captures to complete life-cycle emissions associated with extraction, production and consumption of fuel.

Fleet Conversion Plan

Transitioning from internal combustion engine (ICE) vehicles to EVs can substantially lower overall carbon emissions. It is recommend that the City replace vehicles with EVs after the current vehicle has met its replacement criteria. Early replacement is not assumed in the analysis – simply a year-over-year swap with an EV once the vehicle reaches the appropriate mileage or service life based on the vehicle type (i.e. 12yr/120,000 for most light duty vehicles).



Vehicle Availability

Not all vehicles in the City’s fleet have suitable replacements commercially available. The current EV market is dominated by light duty vehicles, with emerging options in pickup and SUV categories. There currently are no manufactures that outfit an EV for police vehicle use. However, the market is rapidly changing so over the course of the next 5 years new innovation and demand should allow for police patrol vehicles to comes to market. Some vehicles will need to be replaced before there is an EV equivalent on the market, in those cases it is assumed that a new ICE vehicle will be purchased and then will be replaced with an EV in the next cycle. It is assumed all type 2 vehicles (mostly police patrol vehicles) will not have an EV equivalent until 2027 and all type 3, 4, and 5 vehicles until 2030.

Summary of Financial Metrics

EVs have a higher initial capital cost, but lower fuel and maintenance costs than ICE vehicles. Fueling vehicles using electricity is approximately 25% the cost of gasoline. Maintenance costs are 50-75% of gasoline equivalents. Some of the initial cost is offset by federal incentives. Over time, initial costs for EVs are also trending downward as production volumes increase and battery costs decreases.

Over the next 17 years, the Total Cost of Ownership (TCO) of replacing vehicles with EVs would be comparable with ICE vehicles. The amount of CO2 emissions saved would be ~9 million lb. Analysis assumes 2.5% inflation, electric rate inflation of 2.44%, and cost escalation of 2.65%. Initial cost is inclusive of federal incentives for EVs (both passenger and heavy duty).

Fleet Conversion Life-Cycle Cost Analysis (2023-2040)

	Vehicle	Fuel	Maintenance	Total	2023-2040 Life-cycle Emissions	Decarbonized Reduction from Baseline in 2040
Scenario	[\$]	[\$]	[\$]	[\$]	[Tonnes CO ² e]	[%]
Like-for-Like (ICE)	\$14.5M	\$3.9M	\$1.6M	\$20M	7,300	-
Electrified Fleet** (EV)	\$18.0M	\$1.7M	\$1.2M	\$21M	3,100**	97%

**Costs & Emissions are based on the fleet conversion happening over time and account for both costs and emissions associated with the existing ICE vehicles before they are electrified.

Renewably Powerable | Electric Vehicle Charging

Charging Infrastructure

Overview

Fleet electrification requires infrastructure to charge vehicles to they can be used in daily operations. In addition, there is a desire to provide public charging for electric vehicles to encourage residents to drive EVs themselves. **The costs associated with this infrastructure are included in the building decarbonization costs.** This includes any electrical service upgrades needed to accommodate the new electrical demand. Refer to the Building Audit reports for site specific information on EV Charging infrastructure and it’s impacts. Fleet charging should occur almost entirely on-site at City facilities. Charging at publicly accessible stations is much higher cost and adds operational uncertainty.

Charging Power

Charging stations are available in a range of power levels. Level 2 and 3 charging are the most appropriate for fleet use. Level 2 outputs AC power from 7-18kW, adding 15 to 40 miles of range per hour depending on the vehicles type and power level. Level 2 charging requires a 208 volt or 240 volt AC service. Level 3 outputs DC power at 25+ kW and typically requires a 480 volt AC service.

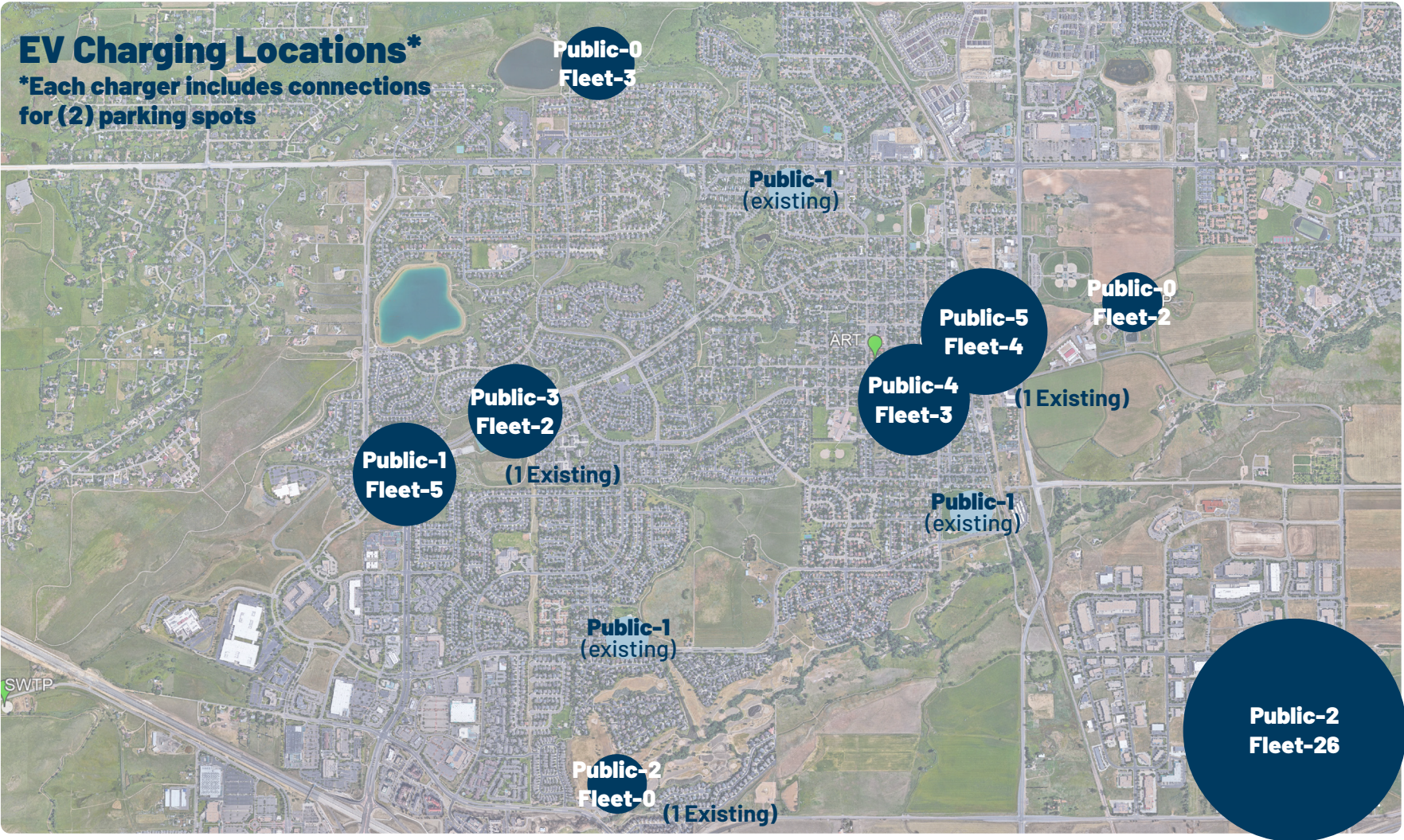
Primarily Level 2 charging for fleet use is recommended, as it provides good value for infrastructure investment when factoring in cost and time required to charge when compared to Level 3 chargers. Level 3 chargers can make sense when high use vehicles need quick recharging, though these chargers will cost more to install and incur a higher charging cost than level 2 chargers.

Public Charging

It is recommended to install a small amount of charging intended to be used by City residents and the general public. These chargers are an important demonstration of the City’s decarbonization efforts and provide a valuable city service for residents. These should be located where the intended use of a site aligns with public use.

Facility	# of EV Charging Parkings Spaces			
	Existing	New		Total
	Public Charging [#]	Public Charging [#]	Fleet Charging [#]	Public + Fleet Charging [#]
Art Center	0	0	0	0
City Hall	0	8	6	14
City Services	0	4	52	56
Coal Creek Golf Course	2	4	0	6
Library	2	10	8	20
Sid Copeland Water Treatment Plant	0	0	6	6
Police and Municipal Court	0	2	10	12
Recreation and Senior Center	2	6	4	12
Howard Berry Water Treatment Plant	0	0	0	0
Wastewater Treatment Plant	0	0	4	4
Total	6	34	90	130

Each EV charger has two charging connections, meaning it provides charging for two parking spaces.



Renewably Powerable | Miscellaneous Equipment Electrification

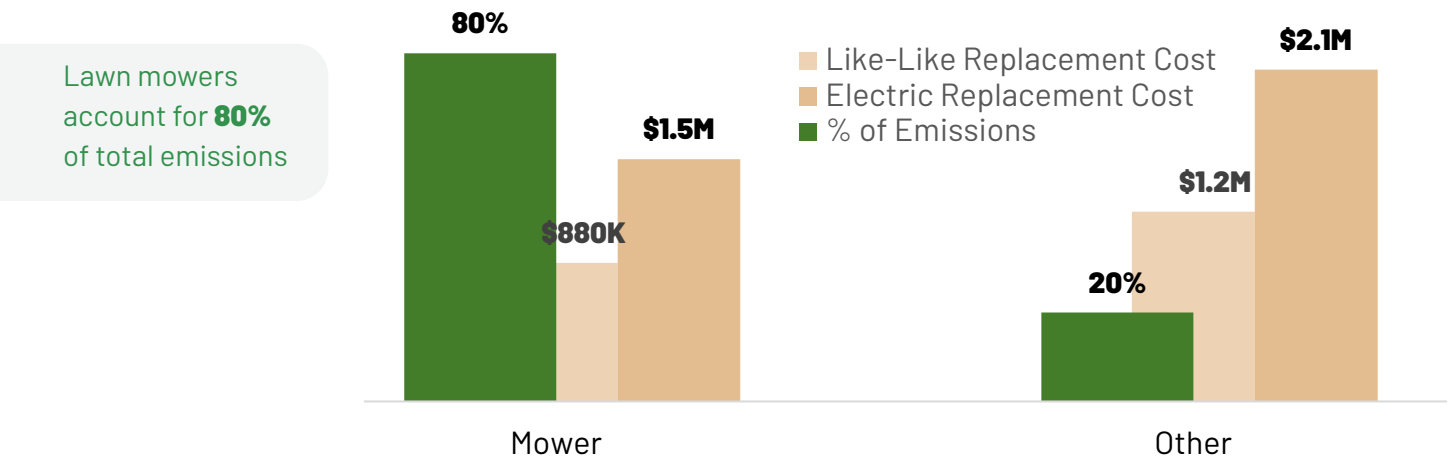
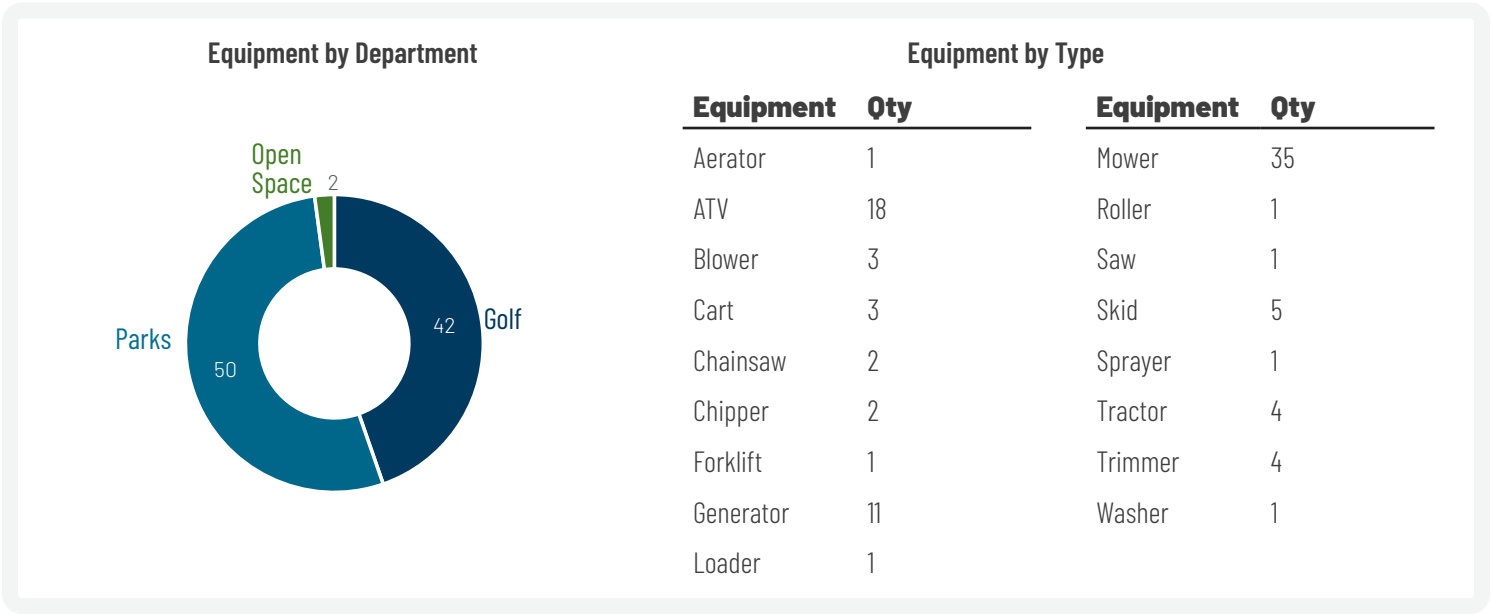
Miscellaneous Equipment Conversion Plan

Small gasoline engines, like those in gas powered riding mowers and garden equipment, are fast becoming a significant contributor to smog forming air pollution. These small engines emit hundreds of times more pollutants per hour than automobile engines.

New lithium battery powered riding mowers, park equipment, and leaf blowers compete effectively compared to gasoline powered tools regarding power and performance, and have significantly longer operating run times than older electric models. On top of that, these new tools are quieter and will not produce the lingering gasoline smells that are an unhealthy indicator of the fumes and pollution that gasoline powered equipment produce.

Current Equipment

The city currently has three departments that own the majority of the small engine vehicles and equipment: the golf department, parks and recreation, and open space.



Small Engine Electrification

Most the small engine equipment type categories currently have electric equivalents available. The categories that do not or have very limited choices are, tractors, skid, loaders, chippers, and rollers. Some of these types of equipment are actively being developed. Additionally, in the mower category there are some specialty golf course lawn mowers that do not have a good electric choice.

Unfortunately, unlike the fleet electric vehicles, most of the electric lawn care equipment does not have battery warranty that matches the equipment warranty. As this technology matures, the warranties will get better.

Another large hurdle for this equipment is the cost of the electrified version. Most electric versions of the non-handheld equipment is about 1.75 times the cost of the gas version. Maintenance costs are lower, but not enough to offset the initial up front cost.

It is recommended to replace existing equipment that is at the end of its life (most large equipment is replaced by the department every 8 years) with the electric equivalent.

Refueling & Charging

With the newest battery technology available, most of the larger equipment is able to operate during a typical work day. This equipment isn’t designed for battery swap out in the field, so if the battery charge got low the operator would need to plug it in somewhere to charge or switch to a different piece of equipment. Typically they would need to switch to a different piece of equipment. The charging time for this equipment isn’t fast enough to get a full charge in a reasonable amount of time. For smaller hand-held equipment, spare batteries can be carried along to change out when the charge gets low. Additional training may be required to get operators use to carrying around extra batteries that are fully charged. When the city switches the fleet vehicles to EV’s, most work style trucks may have the ability to charge auxiliary devices like batteries for small hand held equipment. For most of this equipment it is recommended that everything be charged overnight as it is unlikely that anything would be able to be charged during the day and used that same day.

Charging

Most small motor equipment will require at least a 120v 15amp circuit to charge. It is recommended that there is one dedicated plug for each piece of equipment. Additional electrical infrastructure will be needed to make charging plugs accessible to all equipment where it is stored.

Battery Life

Battery technology is improving significantly year to year. Most batteries are lithium based and have longer life spans than the equipment. Depending on the manufacturer, the battery warranty may or may not match the typical equipment life. For small hand-held equipment, purchasing extra batteries will allow for longer use and does not add much cost. For larger equipment, the battery can be a significant part of the cost and having a second battery on hand will be cost prohibitive. In addition, the larger equipment isn’t always designed for quick battery change outs. Similar to electric vehicles batteries for this type of equipment will eventually have warranty life greater than the cities typical use.

Renewably Powered | Photovoltaics

Photovoltaics

Renewable energy plays the important role of offsetting remaining carbon emissions after building load reductions and electrification has been made. This can be handled through a variety of avenues – behind-the-meter systems, Community Solar Gardens, and utility subscriptions. Since City of Louisville already offsets its current electricity with renewable utility subscriptions, the focus was on customer-owned, behind-the-meter systems that would provide more value to the City of Louisville.

On-site Versus Grid Purchase

Some of the benefits of on-site solar vs renewables purchased from the grid are listed below.

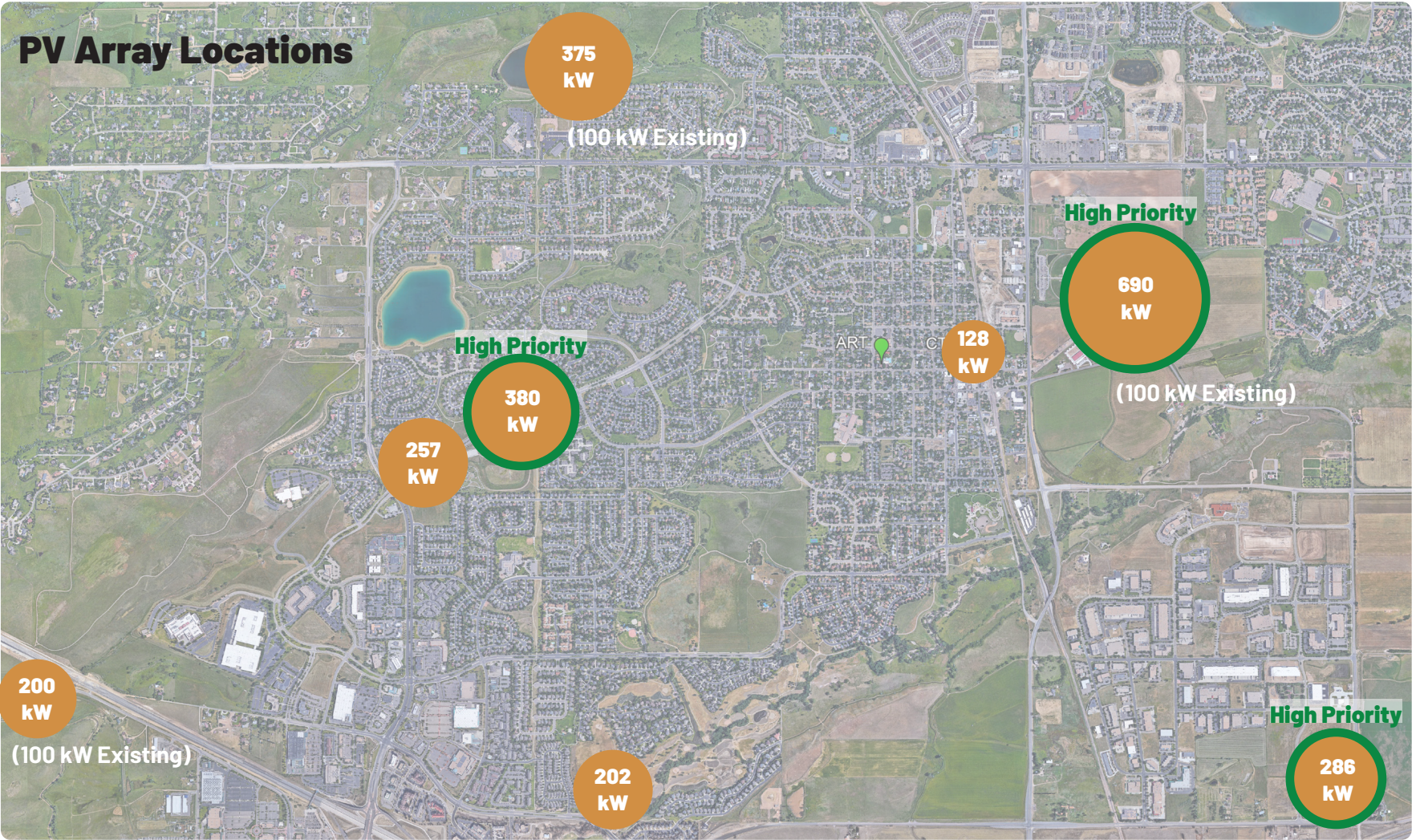
- Avoid solar sprawl at scale – avoiding offsetting of impacts to rural areas.
- Avoid electrical energy loss due to transmitting power over long distances.
- Dispersed approach is typically grid beneficial, especially when on-site renewables are a small percentage of the total usage of building – most solar on this bldg would be self used.
- Enable future resiliency through addition of batteries and storage.
- Demonstrate decarbonization to local Louisville community.

High Priority Sites

High priority sites were recommended based on the following considerations:

- Financial and technical feasibility
- Impact & considerations with land development

Facility	Proposed			
	Array Type [-]	Array Size [kW]	Array Production [kWh/year]	Cost Estimate [\$]
Art Center	None	-	-	-
City Hall	None	-	-	-
City Services	Ground	286	315,000	\$870K
Coal Creek Golf Course	Ground	202	252,000	\$1.2M
Library	Roof	128	174,000	\$520K
Sid Copeland Water Treatment Plant	Ground	375	559,000	\$1.3M
Police and Municipal Court	Ground	257	397,000	\$910K
Recreation and Senior Center	Ground	380	569,000	\$1.2M
Howard Berry Water Treatment Plant	Ground	200	302,000	\$750K
Wastewater Treatment Plant	Ground	690	1,026,000	\$2.1M
Total			3,593,000	\$8.8M



On-Site Design Considerations

Where to create solar arrays: ground, rooftop, or parking canopies?

The first constraint on system size is the available space on the property. Since ground mounted solar arrays are typically the least expensive, this is the first priority, followed by rooftop and then parking canopies. Solar systems benefit from economies of scale – generally, the larger the system, the cheaper it is per kW.

Financial size optimization

In some cases, it is possible to add more solar capacity than can be used by the facility. Typically, based on current regulations, this scenario would mean giving the value of this electricity back to the utility. All recommended on-site solar in this roadmap avoids significant amounts of such value “give back”.

Roof age

Roof membranes and solar PV modules have similar lifespans, about 30 years. De-installation/re-installation of a solar system is costly, creating unviable economics in addition to unnecessary hassle for facilities management down the road. The PV array at the Library is the only recommended system that is roof-mounted. This array should be installed at the time of the Library roof replacement.

Assumed useful life of solar

The National Renewable Energy Laboratory estimates the operational lifespan of photovoltaic systems to be 25 to 40 years, and a recent study by the Lawrence Berkeley National Lab found that utility scale solar developers assume an average useful life of ~35 years. The financial pro forma included in this roadmap assumes a useful life of the ground and canopy mounted solar arrays of thirty years, and 25 years for roof mounted arrays (based on typical 25 year roof life). While this is longer than the warranty period, it is expected the arrays will be functional for this period and potentially beyond. A small output degradation is assumed over time, consistent with standard industry practice. Note the pro forma does assume micro-inverter replacement as part of solar operation and maintenance at year 15.



Credit: Jack’s Solar Garden

Agrivoltaics

The co-location of ground mounted solar arrays and agriculture (such as community pea patches), or carbon sequestering/pollinator habitat restored native meadows, are a great holistic sustainability solution. All ground mount systems should have some component of agrivoltaics to further mitigate carbon whether it’s drought resistant irrigation, pollinator habitats, or wild flowers.

Planting plan for Denver Botanic Gardens Solar Array

Zone 1 Vegetable Production	Zone 2 Pollinator Habitat Cover Crop Rotation	Zone 3 Vegetable Production
Zone 4 Pollinator Habitat Cover Crop Rotation	Zone 5 Native Plant Seed Bank	Zone 6 Vegetable Production

Potential future opportunities for larger-scaled Louisville owned renewables

Virtual net metering

The State of Colorado recently adopted virtual net metering legislation, which potentially enables utility customers with multiple site portfolios to transfer the electricity value of solar production from one location to another. The details of this legislation are complex and still being understood, but over time, it may enable Louisville to look at larger scale opportunities, such as undeveloped land, open water, or park areas to be used for solar production .

Water reservoir or sewage processing pond floating solar

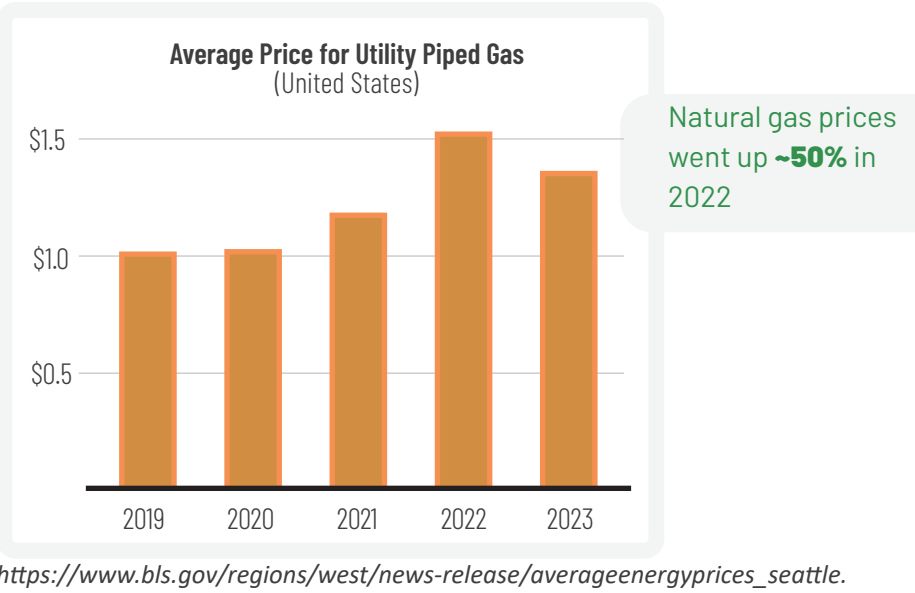
A specific opportunity for larger scale solar (which would require net metering to make financially feasible) is floating solar. An initial evaluation suggests that an array ~400kWdc could sit at the Sid Copeland Treatment Plant reservoir. Typically arrays need to be on the scale of 1-2MW or larger to cost-compete with ground mount options.

Financial Considerations

The process of decarbonization doesn’t occur in a vacuum, and other financial considerations beyond initial costs or utility savings come into play. Different financial scenarios or considerations impact how the cost of decarbonization might be viewed – these are the **additional avoided costs** discussed below. In addition, the process of electrification, in particular, can yield additional benefits– known as **co-benefits**. Where quantification is possible, it is provided, based on economic modeling derived from best and most recent available science. **All figures assume a value stream of the roadmap horizon of 2023 – 2040.**

Additional Avoided Costs

Estimated Avoided Future Carbon Emissions Penalties \$7,335,000	Avoided future carbon emissions penalties As climate change becomes an increasingly current (rather than future) reality, carbon emissions penalties are starting to be applied by leading organizations to internal operations, and by governing bodies as regulation. Colorado recently adopted HB21-1286, which establishes penalties for high Energy Use Intensity private sector buildings, and the City of Denver created Energize Denver, which has even more aggressive carbon penalties. Leading private sector firms, such as Microsoft, also apply an internal cost of carbon to lower immediate emissions and begin bending decision making to anticipate a more aggressive future carbon penalty regulatory environment. The Canadian Federal government recently adopted an internal decision making price of \$261 CDNS/mton, and the EPA has draft rule of \$261US. While these have yet to become actual regulatory penalties, they indicate a likely direction over time as climate change worsens. For this roadmap, an initial penalty stream based on the Colorado carbon price of \$76/mton is applied from 2023-2027, moving to the draft EPA price for 2028-2040.
Estimated Avoided Cost of Future Natural Gas Price Shock \$732,000	Natural gas price shocks Historically, natural gas has substantially greater price volatility than electricity, which isn’t captured by typical escalation rates. The Russian invasion of Ukraine has put a spotlight on the potential for long term natural gas price instability – during 2022, natural gas prices increased by 50%, making previous natural gas escalation rate assumptions of 3-4% invalid. Many risk forecasters anticipate further natural gas instability based on volatility of many producing nations. This roadmap includes a scenario of a second natural gas price shock in 2030, mirroring the impact of the 2022 shock.
Value of Solar for Future Electric Micro-grid Backup Power \$900,000	Future electric micro-grid backup power Currently, emergency power is provided by backup fossil fuel powered generators. A decarbonized alternative, with potentially even greater resiliency, is electric batteries fueled by on-site solar. The cost of batteries for such systems is currently cost-prohibitive, but likely to drop in the future. Installing on-site solar as proposed for overall renewable power for the City has a dual benefit of helping enable future electrical islandability. The value of this is assumed at 10% of the overall cost of proposed on-site solar.



Co-benefits

Employee and visitor health and performance:
Air quality and Thermal comfort

The proposed decarbonization program will also enable improvement of ventilation and filtration systems that are part of HVAC systems being electrified. Demand control ventilation can be added and optimized to better filter media. Elimination of natural gas combustion removes any risk of noxious combustion gasses (NOx, SO2, CO) from malfunctioning exhausts, etc. Air sealing the buildings, which retains tempered indoor air, has the added benefit of excluding smog and wildfire smoke, as well as reducing mold – a substantial benefit. Finally, City Hall currently has very poor temperature control, with overheated and colder work areas. The new electrified and rezoned system will enable more comfortable work temperatures there.

Value of Improved
Employee and Visitor
Health and Performance

\$1,027,000



Employee retention – climate leadership

The cost of employee turnover (training, lost knowledge, etc.) is significant in any organization. Employees take pride in working for organizations which have integrity in reflecting their values. This value stream assumes a 2% reduction in employee turnover due to its expressed climate leadership.

Value of Employee
Retention Based on
Climate Leadership

\$714,000



Additional Co-benefits
[Not Quantified]

Community Decarbonization Education & Leadership Decarbonization is a signal to the community about the importance of the climate action goals the City has set. Specific elements such as heat pumps, renewables, and efficiency measures can be used for classes etc. to inform residents about zero carbon living.

Eliminate Gas Explosion Potential Natural gas is flammable gas that has risk of combustion. While the likelihood is statistically low, the potential cost and impact is extreme.

Eliminate Gas Cooking Burns Natural gas is currently used for cooking in the Golf Course Clubhouse. On-site combustion for cooking can lead to burns and injuries. Induction ranges and electric combi-ovens (which use infrared, microwave, steam, and heat together for great efficiency) reduce those risks.

Louisville “Brand” Louisville’s decarbonization program is leading edge, and if desired, could be used for publicity and to enhance the City’s reputation, with likely economic development benefits.

Job Creation Louisville’s decarbonization work will result in local employment that would not otherwise occur in a business-as-usual scenario.



Annual Operating Expense Impacts

Electrification & Building Utility Cost Impact

Electrification can lead to increased annual utility costs due to the existing utility rate structures, where electric demand charges are high and the cost per unit energy of electricity is typically higher than natural gas. Specifically for Xcel energy, electric demand charges (\$/kW) are particularly high. This makes demand reduction strategies particularly important. Electric energy (\$/kWh) charges for Xcel are lower than most utilities, but are still approximately 50% higher than gas on a \$/kBtu basis.

Building Demand Charges

Hybrid gas systems will also provide value by reducing annual demand (kW) costs in comparison to an all-electric alternative. Gas-backup systems have the option to lockout the primary heating (heat pumps) when temperatures are lower to avoid potentially costly demand (kW) charges. This strategy can help alleviate some of the demand penalty associated with the all-electric option, but it will also incur slightly more energy usage and more fossil fuel combustion.

Renewables

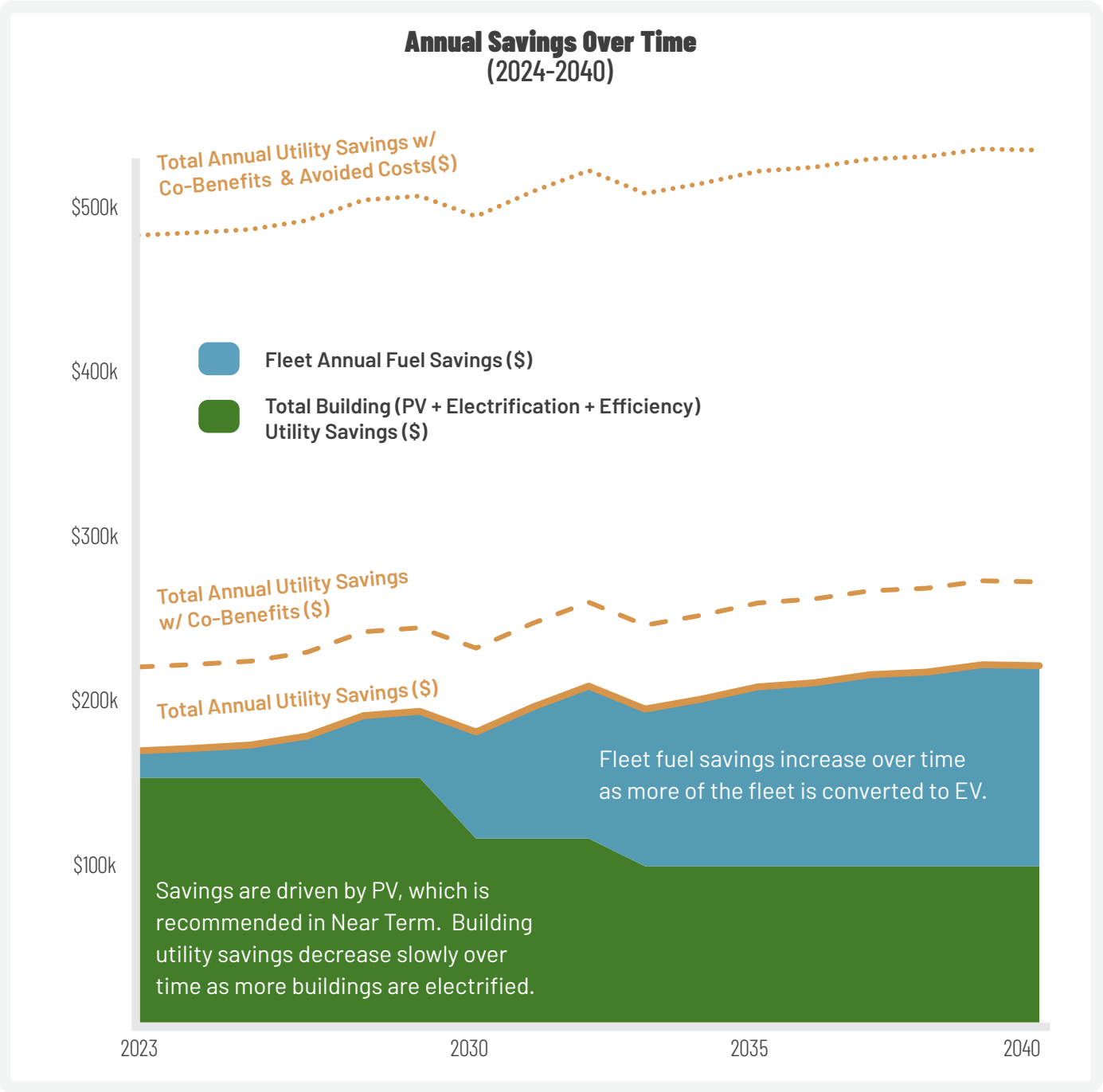
Renewable PV systems account for the majority of the utility cost savings at the building level. Adjusting utility rate schedules based on the recommended PV array was analyzed as part of this study.

Efficiency & Load Reduction

Efficiency & load reduction measures typically have positive utility savings as they do not involve fuel switching.

Co-Benefits & Avoided Costs

Additional benefits realized through the process of electrification. Annualized co-benefits and avoided costs are shown in the figure to the right.



Funding Options

Funding is a critical piece of any decarbonization roadmap to ensure an implementation plan is successfully executed. Over the course of the project, several grant and stimulus funding opportunities were researched and identified along with capital and financing streams that are applicable to the implementation of the City’s roadmap. In addition, interviews with the finance team were conducted, and funding workshops were held in March and May of 2023. Below is a list of applicable funding sources identified to help the City fund and implement the recommendations within the Internal Decarbonization Roadmap. All information below is based on research conducted during the year of the study. Grants and stimulus funding is likely to vary in future years.

Grants and Stimulus Funding*

- Colorado Public Building Electrification Grant**
- Colorado High Efficiency Heating & Appliances Program
- Colorado Department of Local Affairs Grants
 - Energy and Mineral Impact Grant
 - Renewable Energy Grant
 - Climate Resiliency Challenge**
- State of Colorado Geothermal Grant
- Congressionally Directed Spending**
- FEMA Building Resilient Infrastructure and Communities (BRIC) grant
- Inflation Reduction Act
 - Investment Tax Credit – Direct Pay for renewable energy systems, battery storage
 - Grant programs for electric vehicles and electric vehicle charging
- US Department of Energy grants for municipalities
- Xcel rebates
- Mow Down Pollution Grant**
- Charge Ahead Colorado Grant**
- Colorado Fleet-Zero Emission Resource Opportunity (“Fleet-Zero”)**

*The key to successful grant applications: the full application and submitted project needs to move the needle, be “shovel ready”, compelling and create benefits for the community.

** Grants currently being applied for during the 2023-24 fiscal year for project implementation.

Capital and Internal Funding

- Allocate dedicated stream of capital to sustainability during bi-annual budget cycle
- Internal borrowing from enterprise funds with additional capital availability.
 - City has experience with this method of funding projects
 - Some funds are heavily restricted
- Diverted operational/Capital Improvement Plan dollars
- Dedicated sustainability tax – with % earmarked towards municipal & community sustainability projects
 - Investigated in 2023 through Open Space tax extension discussions. Recommend re-investigating in future years.

Financing Options

- **Tax Exempt Lease Purchase** – an installment purchase, conditional sale or lease by a public agency using the installed equipment as collateral and financed by an investor or bank.
- **Bond** – debt obligation issued by a public entity using the loan for public projects, such as constructing buildings, highways, or renovations.
- **Certificates of Participation (COP)** – is a type of financing where an investor purchases a share of lease revenues to secure financing for public sector projects.
- **Energy Performance Contracting** – a contracting and financing tool that leverages multiple sources of funding to construct energy savings projects for public sector agencies.
- **Energy-as-a-service** – a financing tool where a public agencies pays for an energy service without having to make any upfront capital investments and transfers ownership of the capital investment to a third party investor.
- **Infrastructure-as-a-service** – a financing tool where a public agencies pays for infrastructure via an on-going fee or lease payment without having to make any upfront capital investments and transfers ownership of the capital investment to a third party investor.

Funding & Implementation | Financial Analysis

Financial Analysis

A financial analysis was conducted to determine the true cost of decarbonization. This analysis reviewed the like-for-like costs to continue replacing equipment and fleet with the current gas version and compared it to the cost to electrify and decarbonize operations, mechanical equipment and fleet. All costs within this report are turnkey and include final design, engineering, procurement, construction management, and commissioning costs. The financial impact of the project to the City was calculated from 2024 through 2040. The like-for-like project costs were derived from a combination of the City’s CIP budget and detailed cost estimating of turnkey like-for-like equipment replacement as the comparison scenario.

If the City were to continue replacing fleet and mechanical systems with like-for-like gas replacements, the total cost to the City through 2040 would be approximately \$27M with no grants or anticipated utility cost savings. If the City were to electrify all fleet, mechanical equipment and operations, the cost would be approximately \$51.1M including the recommendations of EV charging, load reduction measures, and renewable energy. Decarbonization would allow for the City to capture \$7M in utility and fleet operational savings over the term, secure \$3-13M in grants, incentives and stimulus funding, and help to mitigate the impacts of climate change on the community.

Total Net Cost of Decarbonization =

Total Construction Costs - Total Like-for-Like Construction Costs - [Total Project Savings + Total Grants]

The Summary Table to the right shows the net costs of decarbonization as \$4.4M to \$14.4M depending on the level of grants that the City is able to secure. The co-benefit and avoided costs are not included in this number and would provide an additional \$10.6M in benefits to the City through 2040 for a total potential net savings of \$6.2M over the business-as-usual or “like-for-like” replacement scenario. This number is calculated by taking the gross cost to decarbonize and subtracting out what the City would be spending anyways and the project savings and grants/stimulus.

Summary Table	
Total Construction Costs	~\$51M
Total Like-for-Like Construction Costs (costs that the City would continue to pay)	(~\$27M)
Lifecycle Utility Cost Savings (Utility, Fleet, Solar)	(\$7M)
Total Grants	(\$3M-13M)
Total Net Cost of Decarbonization (varies based on final grant awards)	\$4M-14M

It is recommended that the City do a more in depth financial analysis for each phase to produce a complete and final amortization schedule either internally or with a selected lender. The annual financial model to the right shows annual estimated costs, savings, capital allocation and a summary each year from 2024-2040.

Notes:
Total Construction Costs: Total **turnkey** construction costs needed for budgetary purposes. **Costs do not include incentives or grants. The Inflation Reduction Act will potentially offset 30-40% of the cost of renewables and fleet.**
Total Like-for-Like Construction Costs: The **turnkey** “business as usual” costs for replacing existing fossil fuel equipment with similar fossil fuel equipment. Costs were derived from a combination of the City’s CIP budget and detailed cost estimating of equipment replacement as the comparison scenario.

Turnkey Costs: Include design, engineering, construction management, project management, and commissioning.

Annual Financial Model									
Year	Total Construction Costs	Solar IRA Direct Pay (30%)	Total Grants	Annual Electrification Utility Cost Savings	Annual Efficiency Utility Cost Savings	Annual Solar Utility Cost Savings	Annual Fleet Utility Cost Savings	Total Like-for-Like Construction Costs	Total Net Cost of Decarbonization
2024	\$23,979,948	\$0	\$8,000,000	(\$82,000)	\$44,000	\$335,000	\$33,000	\$10,185,000	\$5,465,000
2025	\$629,972	\$2,692,000	\$100,000	(\$82,000)	\$44,000	\$335,000	\$36,000	\$599,000	(\$3,094,000)
2026	\$244,741	\$0	\$100,000	(\$82,000)	\$44,000	\$335,000	\$40,000	\$201,000	(\$393,000)
2027	\$661,949	\$0	\$100,000	(\$82,000)	\$44,000	\$335,000	\$51,000	\$622,000	(\$408,000)
2028	\$538,469	\$0	\$100,000	(\$82,000)	\$44,000	\$335,000	\$76,000	\$469,000	(\$404,000)
2029	\$255,583	\$0	TBD	(\$82,000)	\$44,000	\$335,000	\$81,000	\$213,000	(\$335,000)
2030	\$8,796,674	\$0	TBD	(\$157,000)	\$44,000	\$335,000	\$130,000	\$4,253,000	\$4,191,000
2031	\$1,126,108	\$0	TBD	(\$157,000)	\$44,000	\$335,000	\$160,000	\$843,000	(\$99,000)
2032	\$638,869	\$0	TBD	(\$157,000)	\$44,000	\$335,000	\$186,000	\$478,000	(\$247,000)
2033	\$5,449,661	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$192,000	\$2,654,000	\$2,415,000
2034	\$537,051	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$204,000	\$402,000	(\$258,000)
2035	\$3,440,025	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$219,000	\$2,574,000	\$458,000
2036	\$775,290	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$224,000	\$580,000	(\$218,000)
2037	\$783,153	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$234,000	\$586,000	(\$226,000)
2038	\$297,040	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$237,000	\$222,000	(\$351,000)
2039	\$1,923,560	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$246,000	\$1,439,000	\$50,000
2040	\$847,035	\$0	TBD	(\$190,000)	\$44,000	\$335,000	\$245,000	\$693,000	(\$280,000)
Total	\$50,925,129	\$2,692,000	\$8,400,000	(\$2,483,000)	\$748,000	\$5,695,000	\$2,594,000	\$27,013,000	\$6,266,000

Implementation Options

Delivery and implementation of the decarbonization plan is laid out through 2040. As part of this analysis, it is recommended that full decarbonization is pushed to 2040 due to technology barriers and the recommendation of not replacing fleet and equipment before the end of its useful life. Three primary methods are recommended for the City to consider for implementation of all phases of the roadmap and outlined below. Due to the complexity, uniqueness and scale of the recommendations, three larger phases or mobilizations are recommended for the implementation portion of the project to reduce the burden on staff, consolidate resources and gain cost efficiencies by scaling the project. The methods below are chosen to account for the metrics above and to lower the overall cost to the City through efficiencies and to reduce the amount of resources needed throughout each phase (versus a piecemeal approach).



Energy Performance Contracting

This method utilizes a state-supported program through the Colorado Energy Office that has been used for over 200 projects within public agencies in the state of Colorado. Energy Service Companies are pre-qualified through the State to assist local governments within turnkey implementation of decarbonization projects for fleet and buildings. This approach allows for flexibility in project funding with the ability for the public agency to combine multiple funding avenues such as grants, stimulus, capital and third party financing. This approach is recommended for the larger, complex buildings that require renewable energy, load reduction measures, electrical upgrades, and mechanical electrification as a single project or construction mobilization such as at the City’s recreation center. Energy performance contracting enables a jurisdiction, to “surge” a major decarbonization effort and avoid the quick ramp up/ramp down staffing impacts that would otherwise be required to manage such projects.

Further information can be found here: <https://energyoffice.colorado.gov/clean-energy-programs/clean-energy-financing/energy-performance-contracting>

When to Use:

Ph1 Renewables

Ph1 Load Reduction

Ph. 1-3 Mechanical

All Buildings

Larger Systems

Some EV Charging



Design-Build or Design-Bid-Build

Traditional method for construction projects where the City would project management and bid out individual scopes of work for design, construction or both. This is recommended for smaller, less complex buildings and scopes of work that require a simple like-for-like replacement of mechanical systems such as the Art Center.

When to Use:

Smaller HVAC Systems

Mid Term Art Center



Self-Implementation

This method is recommended for scopes of work that the City can conduct internally if staff time and resources allow. This method is recommended for equipment replacements (golf carts, lawn mowers, etc) and EV charging infrastructure.

When to Use:

EV Charging

Fleet Purchase

Misc. Equipment

