



City of Louisville

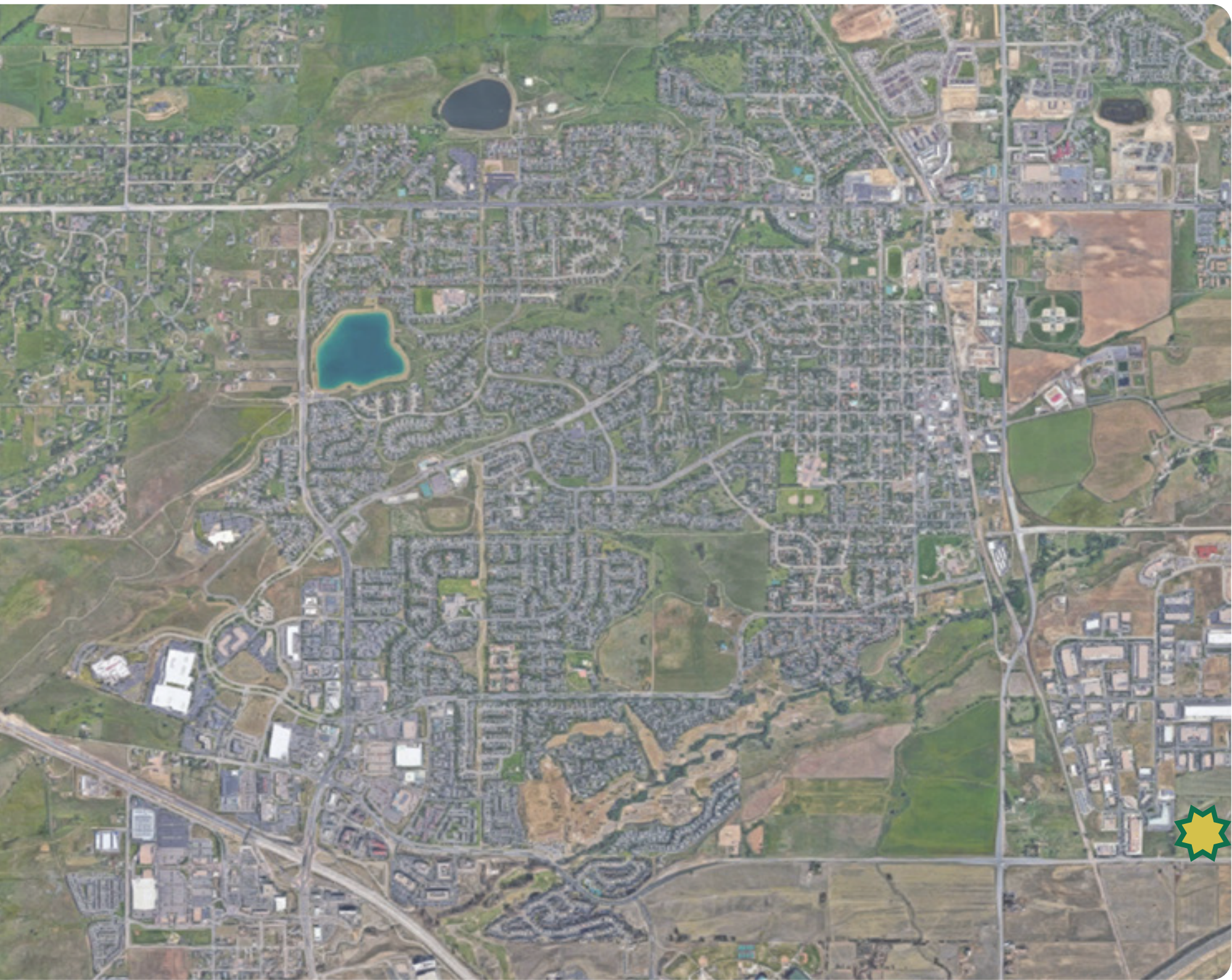
Internal Decarbonization Plan

CITY SERVICES DECARBONIZATION AUDIT REPORT

739 S 104TH ST
LOUISVILLE, COLORADO
AUGUST 18, 2023



Table of Contents



SECTION 1:

EXECUTIVE SUMMARY..... 3

SECTION 2:

BASELINE..... 4

SECTION 3:

DECARBONIZATION MEASURES..... 5

SECTION 4:

NEXT STEPS 11

APPENDIX..... 12

MECHANICAL SYSTEM MATRIX OPTIONS

MECHANICAL DECARBONIZATION SCOPING

ELECTRICAL DECARBONIZATION SCOPING

STRUCTURAL SCOPING

ELECTRIC VEHICLE CHARGING NARRATIVE

RENEWABLES SCOPING

COST ESTIMATING

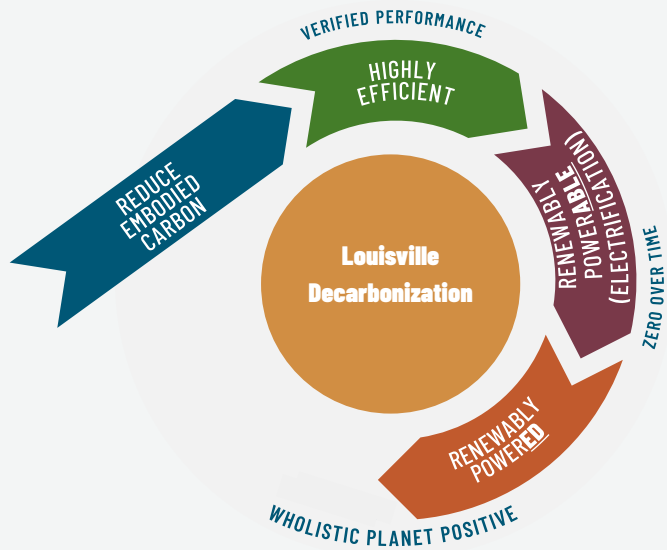
Date	Version History
8/18/2023	Version 1 - Issued to City

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. This resolution sets goals to meet all of Louisville’s municipal electric needs with 100% carbon-free sources by 2025, and to reduce core municipal greenhouse gas emissions annually below the 2016 baseline through 2025. The City of Louisville has demonstrated its commitment toward creating a healthy and sustainable environment for its residents, evident through Resolution 25-2019 (Setting Clean Energy and Carbon Emission Reduction Goals), as well as their Sustainability Action Plan (adopted in October 6, 2020). In support of these goals, McKinstry was contracted to identify a strategic roadmap for electrification and decarbonization of all City buildings, fleet, equipment and operations by 2030, and recommend an alternative target if appropriate.

This is an interim report, providing initial directions, findings, as well as a draft set of detailed decarbonization approaches for the City Services building.

There are many possible pathways for decarbonizing Louisville. With guidance from City staff, this report focuses on identification of strategies that provide the highest value, most fiscally responsible path forward to achieve Louisville’s decarbonization goals.



Decarbonization Recommendation

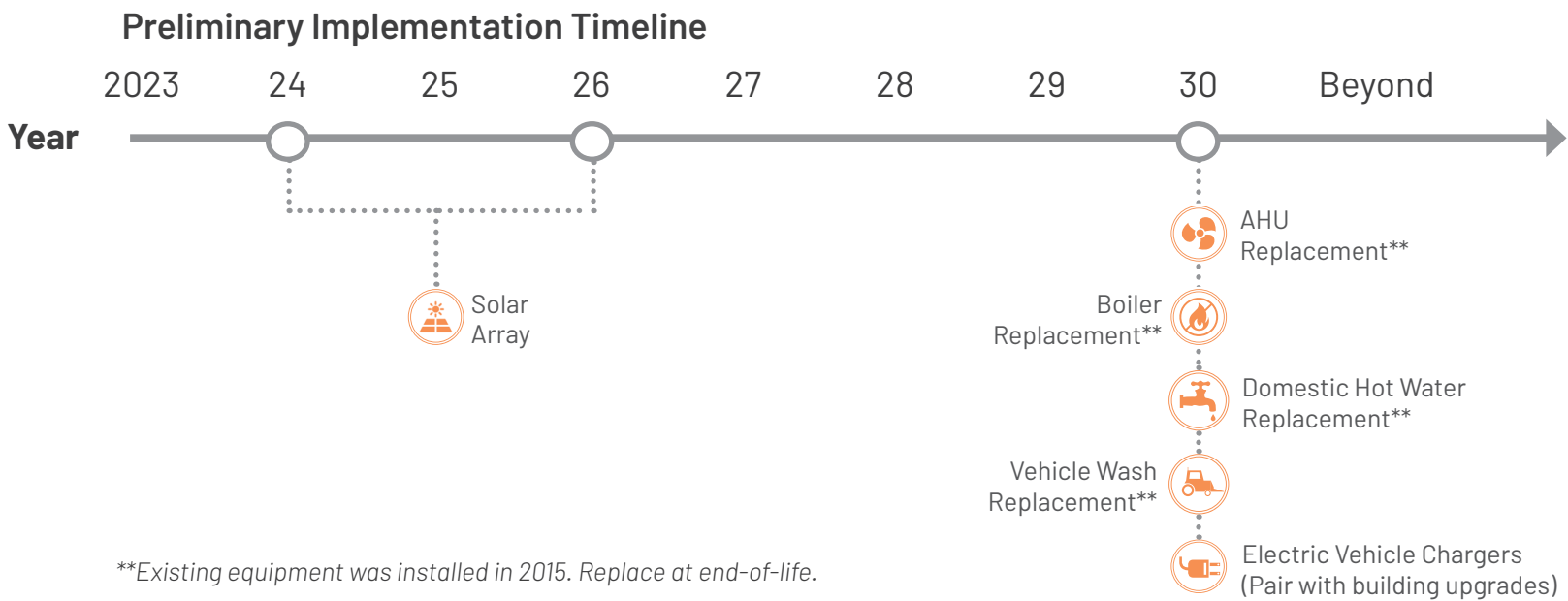
The table below outlines the findings of the study and highlights the opportunity towards a viable and cost-effective path towards carbon neutrality. The total cost is the total amount of money that will need to be allocated for budgetary purposes. The net cost is the total construction costs minus the replacement costs that would’ve been spent to replace the existing units with like-for-like fossil fuel units. The net cost represents the true cost of this decarbonization effort. All information included in this table is explained in greater detail in this report. **These are “all-in costs” and represent the total cost of construction. They are also Rough Order of Magnitude (ROM) numbers, with a +/-20% range.** See “Construction Pricing Context” section for more detail.

	Scenario	Life Cycle Carbon Reduced	Life Cycle Carbon % Reduction	Total First Cost	Net First Cost Over Business as Usual Cost
	Full Electrification	4,500 tons	100%	\$3.1M	\$1.2M
	Renewables	N/A	N/A	\$870k*	N/A
	EV Charging	N/A	N/A	\$1.1M	N/A

*Renewable costs do not account for funding from the Inflation Reduction Act (IRA).

Implementation

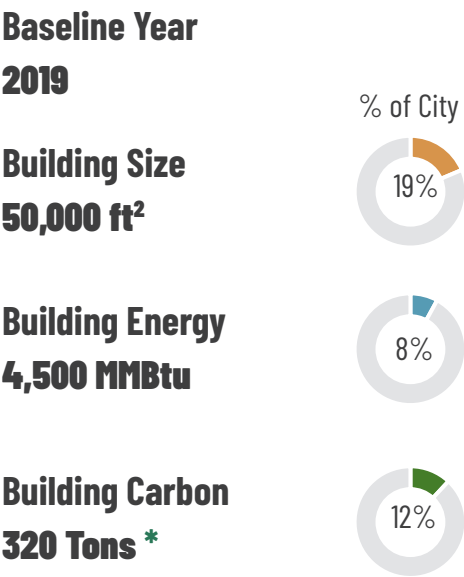
A preliminary implementation timeline is shown below, based on the 2023 Capital Improvement Plan (CIP).



**Existing equipment was installed in 2015. Replace at end-of-life.

Baseline | Building Use & Energy and Carbon Analysis

Baseline Building Use



Building Information

- City Services for Louisville.
- Located at south-eastern border of the city.
- Not open to public.
- Hosts the majority of the City’s vehicle fleet.
- Fleet maintenance and cleaning.

Recent Renovations and Energy Improvements

- None – built in 2015.

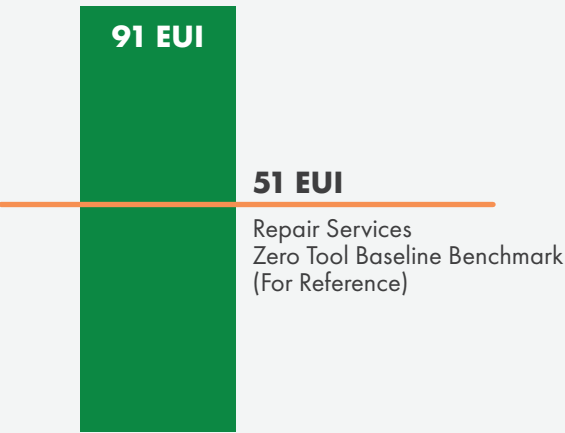
* Note: This does not include emissions from the fleet vehicles.



Baseline Energy Use

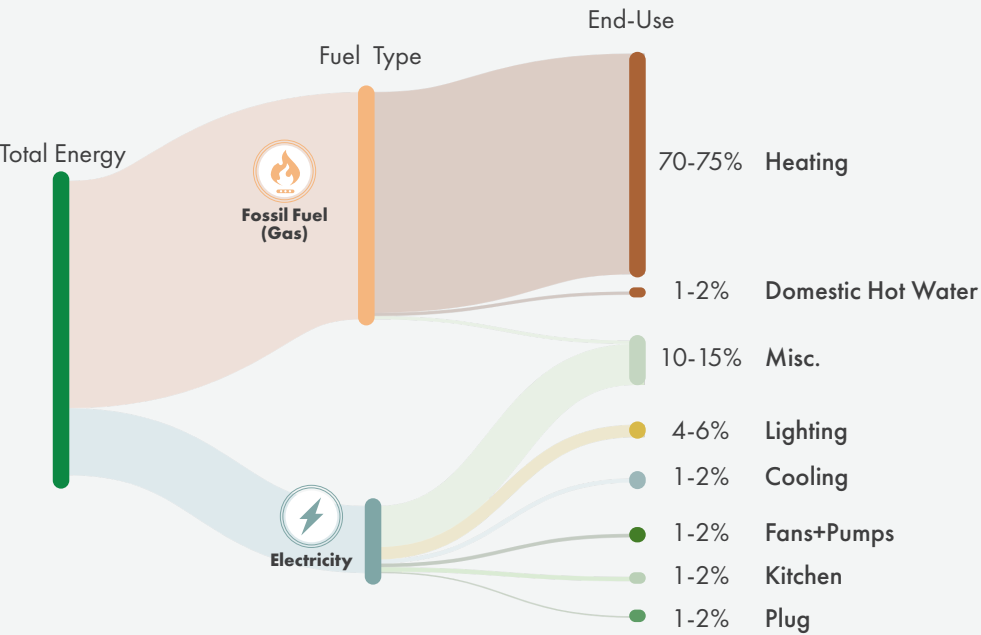
The Golf buildings perform average when compared to the Portfolio Manager Benchmark for repair service facilities.

Baseline Annual Energy Use Intensity (EUI)



Baseline Energy End-Use

Energy end-use estimates are based on most recent available 2018 Commercial Building Energy Consumption Survey (CBECS) benchmarking data and site audit information.



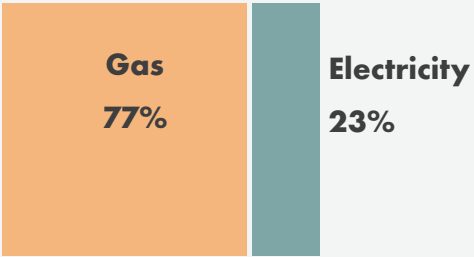
Baseline Carbon Use

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.**

The amount of electric consumption offset needed for zero carbon will be addressed in future phases of this study, and will be evaluated at the portfolio level. The offset will be a function of post-decarbonization electrical consumption considering carbon and load reduction measures, on-site renewable energy provided, and the grid emissions of Xcel Energy and zero-carbon utility subscription programs.



Baseline Energy



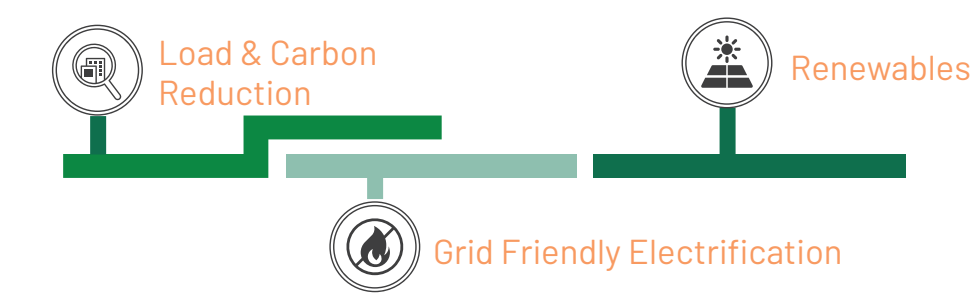
Baseline Carbon



Decarbonization Measures | Decarbonization Process, Load & Carbon Reductions

Decarbonization Process

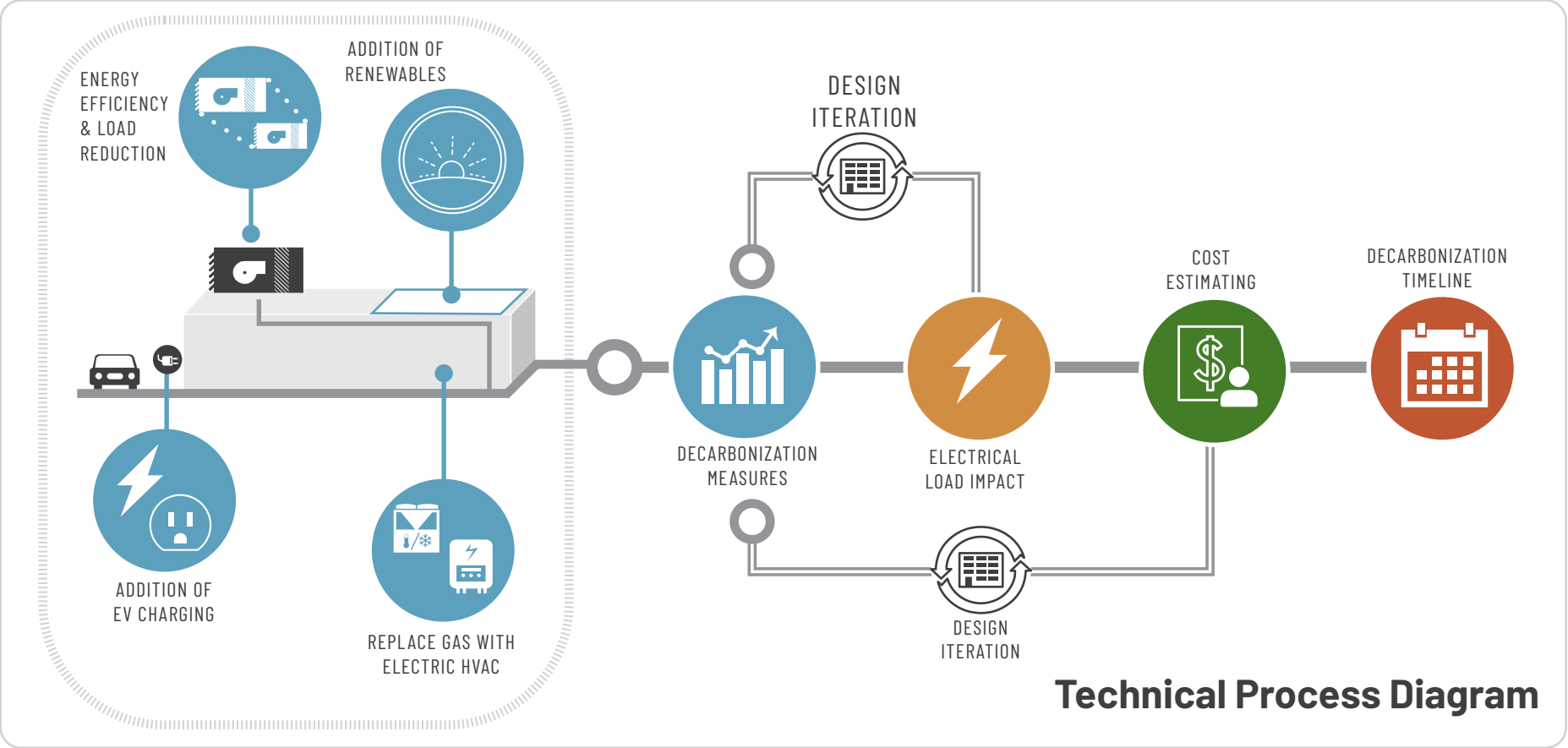
There are a host of measures to employ on the path of decarbonization, ranging from time-tested traditional energy efficiency measures to the more aggressive electrification measures. The key to decarbonization is finding the right balance between measures, as indicated by the graphic below. With this approach, Louisville will find the most cost-effective path to full decarbonization.



The decarbonization solution starts by identifying measures at the building, and continues with design iteration to arrive at the final timeline, as seen in the Technical Process Diagram.

Load & Carbon 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.

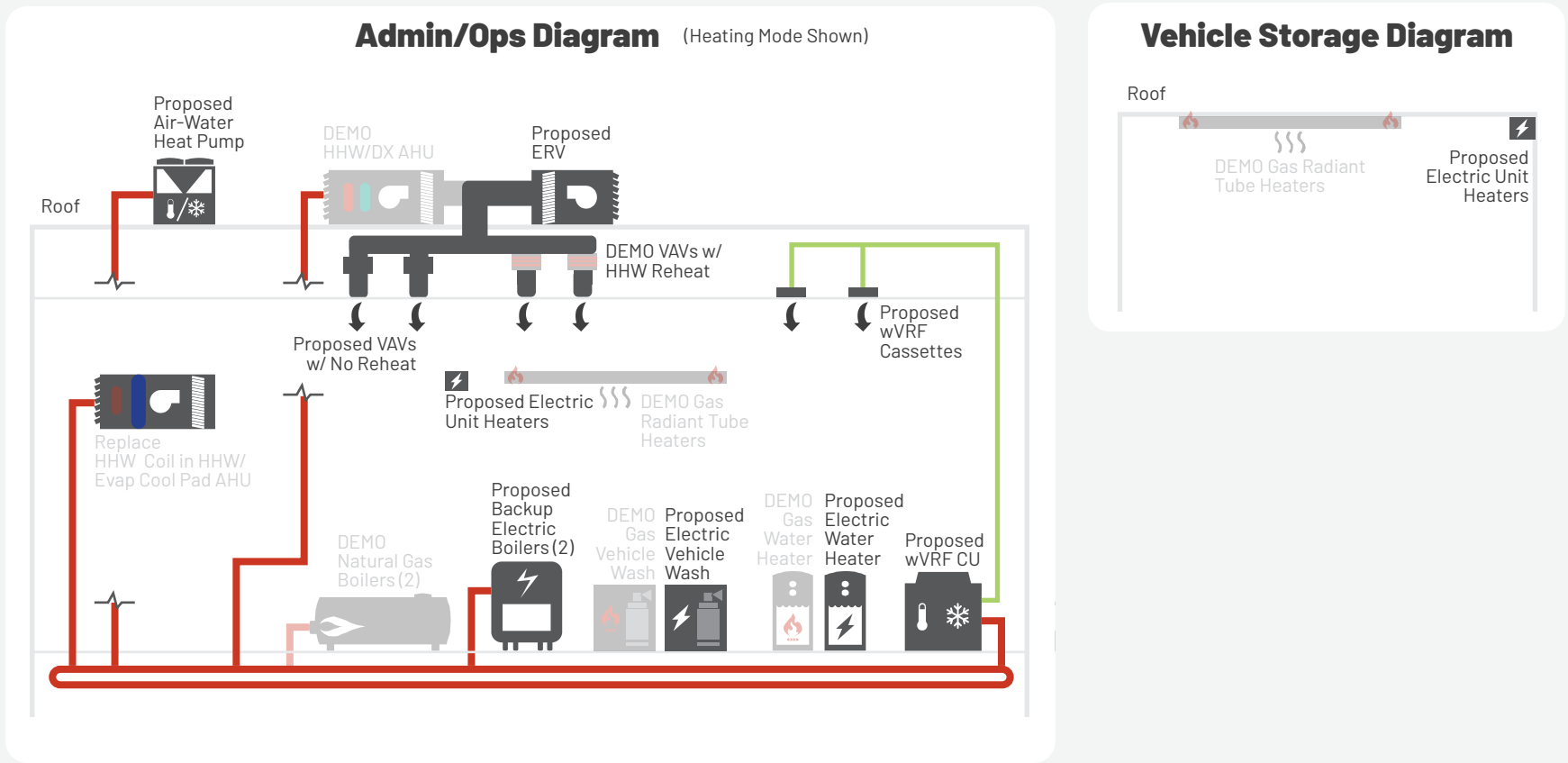


Load	Carbon	Measure	Description
■	■	ENVELOPE AIR SEALING	Buildings are often remarkably leaky – the wall/parapet junction being a frequent culprit. Ensuring a building is tight and ventilated correctly is an effective efficiency measure that also has durability benefits (condensation often occurs at air leakage points) and improves air quality (mold reduction and limiting outside air infiltration during wildfire events).
■	■	COMPRESSED AIR LEAKS	Compressed air systems generally have numerous leaks that go unrepaired. These leaks are very costly and can result in very high utility costs. By finding and repairing these leaks the compressor lifetime will be extended and typically improve performance of the overall system.
□	■	CONTROLS OPTIMIZATION/RETRO-COMMISSIONING (RCx)	Ongoing commissioning can help reduce energy use. This work focuses on identifying low- and no-cost opportunities to drive energy savings and optimize operational practices in the facilities. This is primarily accomplished through ongoing site audits, data analysis, training, and collaboration with the facility's operational team.
■	■	ADVANCED PLUG LOAD REDUCTION	Items that are plugged into outlets –plug loads– often make up the single largest use of electricity in buildings, after heat pump heating and cooling. A dedicated, ongoing program for ensuring plug load items are operating at maximum efficiency and/or appropriately switched is a great way to save electricity.

Decarbonization Measures | Mechanical Electrification

Proposed Electrification

City Services is composed of two parts: the Administration/Operations building and the Vehicle Storage building. The Admin/Ops building is served by (2) gas boilers that supply hot water to a radiant floor loop, 2 air-handling units, and fan-powered terminal units with reheat coils. Other gas equipment includes a gas-fired water heater and a gas-fired unit for pressure washing city vehicles. The Vehicle Storage building is heated by gas radiant tube heaters for freeze protection. Simple diagrams of these systems and their proposed electrification measures are shown below.



AIRSIDE

(2) Air-handling units currently provide conditioned ventilation air to the spaces. AHU-1 uses hot water heating and DX cooling and serves the office side, AHU-2 uses hot water heating and evaporative cooling and serves the vehicle side. To fully electrify, replace AHU-1 with an Energy Recovery Ventilation (ERV) unit for dedicated ventilation and a water-sourced VRF system that ties into the existing condenser/radiant floor loop. Install new FPVAV boxes for ventilation only with no reheat.

HYDRONIC

(2) Gas boilers supply hot water to the radiant floor loop, AHU hot water coils, and FPVAV reheat coils. To fully electrify, replace the gas boilers with an air-water heat pump and install (2) electric boilers as a backup heat source. The equipment hot water coils are sized around a 180deg. F design temperature, but heat pumps can generally only produce about 120 deg. F water. The HHW coil in AHU-2 will need to be resized and replaced to continue meeting demand requirements with a lower loop temperature.

DOMESTIC HOT WATER

DHW in the Admin/Ops building is currently served by an existing gas water heater, to be replaced with an electric water heater.

FUTURE MECHANICAL SYSTEMS FOR CONSIDERATION

The mechanical drawings indicate that the primary heating equipment is oversized compared to typical design benchmarks. The extra heating capacity is used to heat the vehicle area to 60deg. F at all times to prevent salt from freezing in the city vehicles, which has been an issue in the past. In the future, it may be more energy-efficient and cost-effective to decouple the salt-melt heating from the primary space heating systems. Potential solutions include localized heating for the salt, heated beds in the trucks holding the salt, or alternative salt products.

HEATING EQUIPMENT SIZING

A central tenant of the proposed mechanical measures is to downsize the primary heating equipment capacity by 40% to better match typical expected loads during the majority of the year. This approach yields better efficiency, lower utility bills, and less first equipment cost. Preliminary analysis indicates the smaller equipment can still meet building heating loads and prevent vehicle salt buildup. These assumptions should be revisited during the next phase of design.

All Electric vs Hybrid Systems

Based on the sizes of the mechanical equipment, the load profile of the building, and the addition of EV charging, there is no need for a Hybrid option for the City Services buildings. Even the smallest of the proposed electrification measures would exceed the available capacity of the existing electrical service and would require an electrical service upgrade.

Beneficial Electrification

Electrification of mechanical systems provides value beyond energy and carbon savings. Additional benefits include, but are not limited to:

- Enhanced ventilation control (outside-air supply, CO₂ Control, etc.) with new ERV and AHU
- Improved thermal comfort with VRF system, right-sized equipment and updated controls
- Improved resiliency of newer units

Decarbonization Measures | Renewables & Electric Vehicle Chargers

Renewables

At City Services, Louisville could install a ~220.3 kW-DC fixed-tilt ground-mounted solar PV system to offset existing site consumption. Renewable energy plays the important role of offsetting remaining carbon emissions after building load reductions and electrification are complete. 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, we focused on customer-owned, behind-the-meter systems that would provide more value to the City of Louisville.

When evaluating this site, the following factors were considered:

AVAILABLE SPACE & RACKING MODALITY

The first constraint on system size is the available space on the property. Since ground-mounted PV systems are typically the least expensive racking modality, we evaluate this first 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. Just South of the facility, the Louisville Recreation Center could fit a 220.3kW-DC ground-mount array. This could be expanded to a total of 284.6kWdc as site usage increases. The rooftop has several faces that are relatively open and uncluttered by rooftop equipment that could be utilized for future expansion of the solar system as on-site loads increase.

The field to the West was also evaluated, but this option was ruled out in order to allow for future expansion.

SIMPLE PAYBACK

Payback is an easy way to determine the value of a solar system. Solar PV systems last around 25–30 years. McKinstry typically only recommends systems that – including Inflation Reduction Act credits, utility incentives, and/or other funding sources – will pay back within the system lifetime. At this stage of evaluation, simple payback is used. However, if the project advances, more detailed cash flows and paybacks can be calculated.

INTERCONNECTION METHOD & INCENTIVES

Due to size and value of utility savings, City Services arrays would interconnect behind the utility meter and would qualify for Xcel’s Solar*Rewards C&I incentives. These arrays were not considered for Community Solar since those gardens must typically be much larger (500kW-AC+) to make financial sense. Additionally, this solar project would be eligible for Inflation Reduction Act incentives, giving 25–30% of the solar cost back to City of Louisville depending on the chosen financing mechanism.

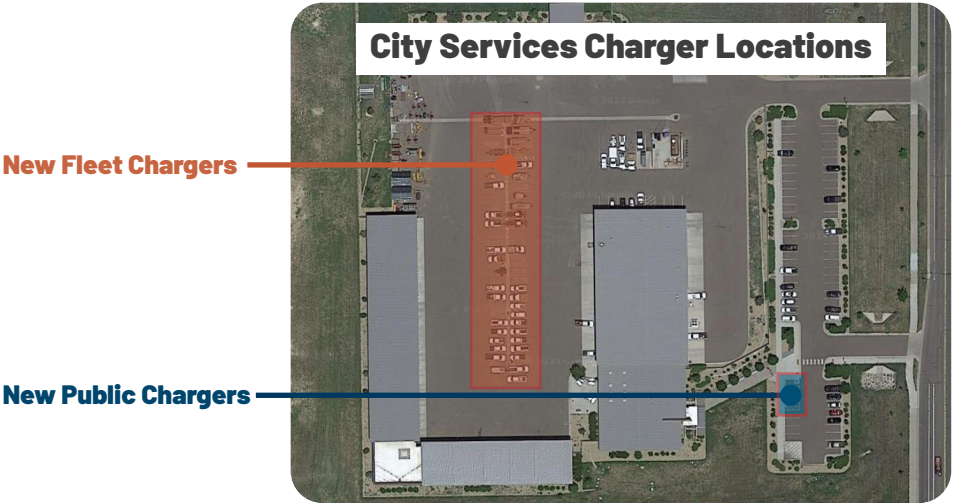
STRUCTURAL CAPACITY

There is limited rooftop structural capacity at this site. Atop the Western and Southern buildings, solar can be centralized on the existing main structural members. Atop the Eastern building, the roof would require structural reinforcement to the current framing to be suitable for PV. As we are proposing a ground-mounted system, future roof installation would need to be further vetted with racking drawings and structural evaluation.



Electric Vehicle (EV) Chargers

The majority of the city’s fleet is stored at City Services, approximately ~71 vehicles. Most are considered heavy-duty vehicles, primarily used around the city for maintaining the parks, buildings, and roads.



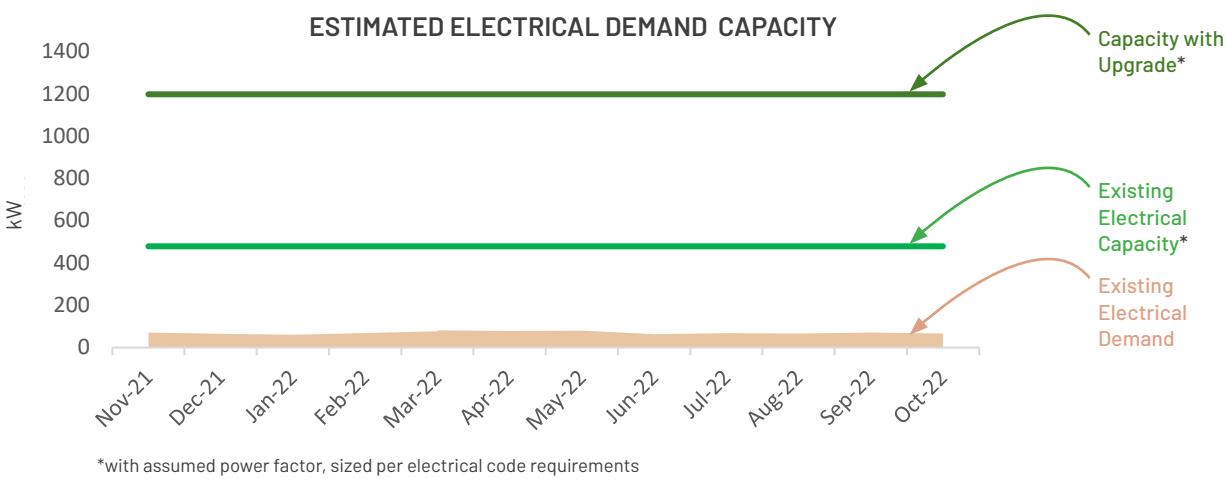
Existing Public Charging Stations	Existing Public Charger Level	Quantity of New Level 2 Public Chargers	Quantity of New Level 3 Public Chargers	Quantity of New Level 2 Fleet Chargers	Quantity of New Level 3 Fleet Chargers
0	N/A	2	0	23	3

We recommend installing 26 dual-head chargers for the fleet and upgrading the electrical infrastructure to support them. This does not allow for every vehicle to be able to charge at once, but there are several vehicles that are only used seasonally. Most of these vehicles are consider heavy duty and currently there is no direct replacement for these types. It is anticipated those vehicles will be available in the next 5 to 10 years. We also recommend installing 2 publicly available dual-head chargers for the city residents.

Decarbonization Measures | Electrical and Structural Impacts

Electrical Impacts

The existing service to the City Services facility is 480 Volts (V), 3-phase, 800 Amps (A). Utility data was analyzed for the date range 11/2021 – 10/2022. This data shows the existing annual maximum demand of the City Hall is 79kW and 65kW during heating season. Accounting for demand factor adjustment, only 109A of winter demand is utilized on the existing 800A service, leaving 691A of extra capacity for new mechanical electrification and EV charging loads.



Load addition at the facility includes Mechanical HVAC and Domestic Hot Water load (requiring 1070A of service capacity), electric vehicle wash (requiring 53A of service capacity), and EV charging load (requiring 599A of service capacity). The total resultant 3-phase service load is 1,831A. This load addition will require a service upgrade to 2,000A and a likely upgrade to the existing Xcel energy transformer.

A new 2,000A service switchboard will be located either inside the facility or outside on an exterior wall. The service switchboard will act as the interconnect point for a possible PV array, outlined separately in this report. The PV array could be as large as 1.3MVA (AC), however the base scope is based on 650kVA (AC).

Significant new conduit runs through the building and additional electrical distribution equipment is required to serve the new mechanical and EV charging equipment within the facility. It should be noted that future changes in building occupancy or consumption patterns from the date range where data was provided may impact the service demand and available capacity for electrification.

The existing facility diesel generator (400kW/500kVA) will be retained and is sufficient to serve the loads requiring backup power. Backup fossil fuel heating equipment is retained to provide backup conditioning in the event of a power outage only. Providing backup heat in this fashion is typically both more cost effective and energy efficient than providing it via a backup generator and electrified heating equipment.



Structural Impacts

No structural upgrades are triggered with AHU replacement. The new unit is lighter than the existing and the underlying support framing is presumed to be adequate for the revised loads.



Decarbonization Measures | Proposed Electrification

Electrification



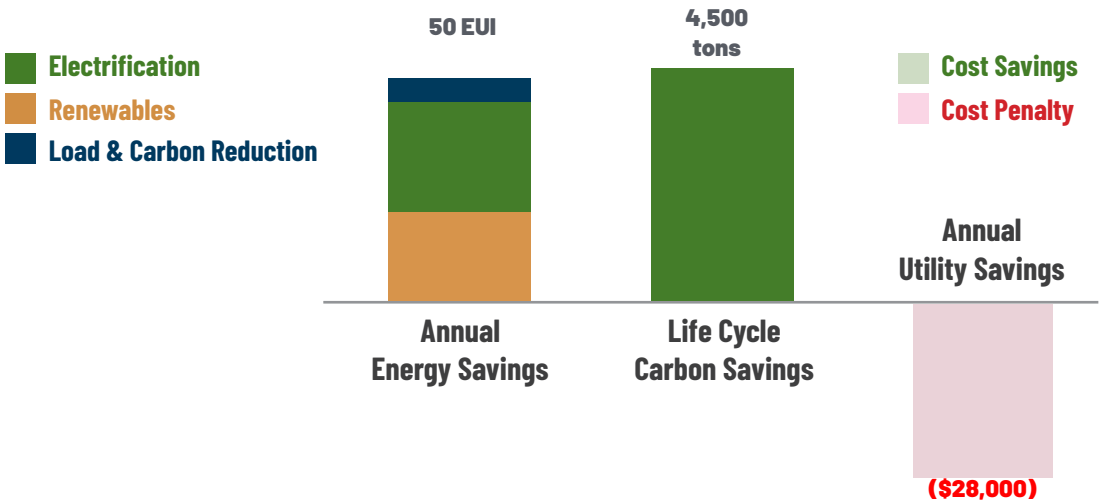
FULL ELECTRIFICATION – Full electrification at City Services, including an air-water heat pump, backup electric boilers, an energy recovery ventilation unit, a water-source VRF system, Vehicle Wash pressure wash equipment, and electric domestic water heating. EV charging costs are not included in this option.

	Load & Carbon Reduction	Grid Friendly Electrification	Renewables
	Controls Optimization/RCx Envelope Air Sealing Compressed Air Leaks Plug Load Reduction	Electrification Full	On-Site Ground Mount PV
Total Cost	\$70k	\$3.1M	\$870k*
Base Cost	N/A	\$2.0M	N/A
Net Cost of Electrification	N/A	\$1.1M	N/A

*Renewable costs do not account for funding from the Inflation Reduction Act (IRA).

Proposed Annual Measure Savings

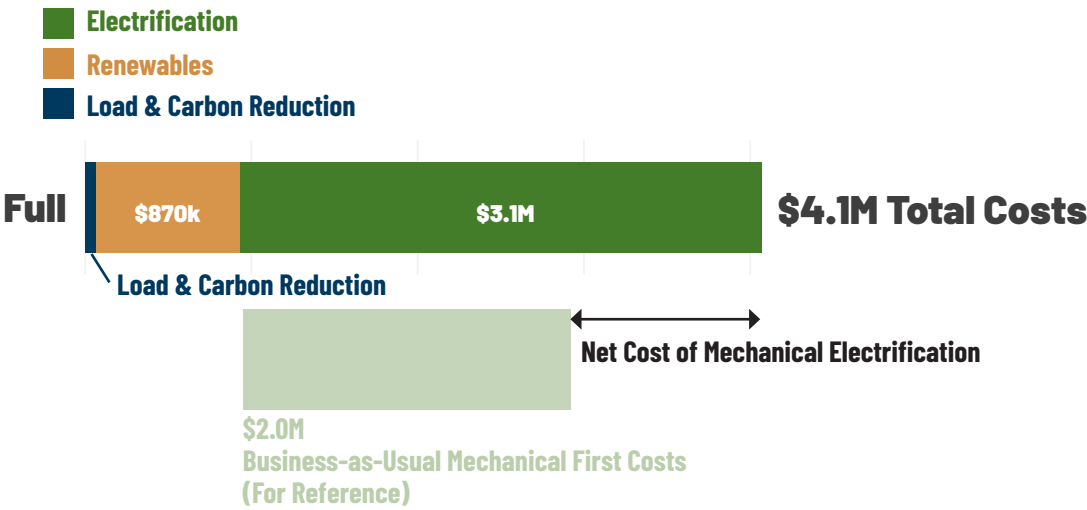
Energy, carbon, and utility cost savings for the full electrification project are shown here. Note that a large portion of the energy savings come from the renewable PV system but all of the carbon savings comes from the electrification measures. The utility penalty is from electrification only.



Proposed Total Measure Costs

Proposed measure costs are shown below, including any structural and electrical upgrades needed for each option. They are also Rough Order of Magnitude (ROM) numbers, with a +/- 20% range.

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.



Decarbonization Measures | Construction Pricing Context & Constructibility

Construction Pricing Context

The MEP scope narratives described in previous sections and included in the appendices were used by McKinstry’s construction division to provide Rough Order of Magnitude (ROM) pricing. This early ROM budgeting process sought to be reasonable but conservative wherever possible. **Typically for ROM-level pricing a range of +/- 20% is applied to the total construction and start up costs.** This range can be reduced, and the pricing further refined, via a deeper understanding of existing building conditions and detailed design. Note this does not account for escalation, which is addressed separately. This pricing represents the total construction and startup cost to Louisville, including:

- General contractor markup
- Design fees
- Engineering energy analysis
- Controls
- Equipment startup, commissioning, testing, and balancing
- Placeholders for miscellaneous trades (e.g. carpentry).
- Allowances specific to each building for construction conditions (e.g. crane time)

All construction costs are in 2023 dollars unless noted otherwise.

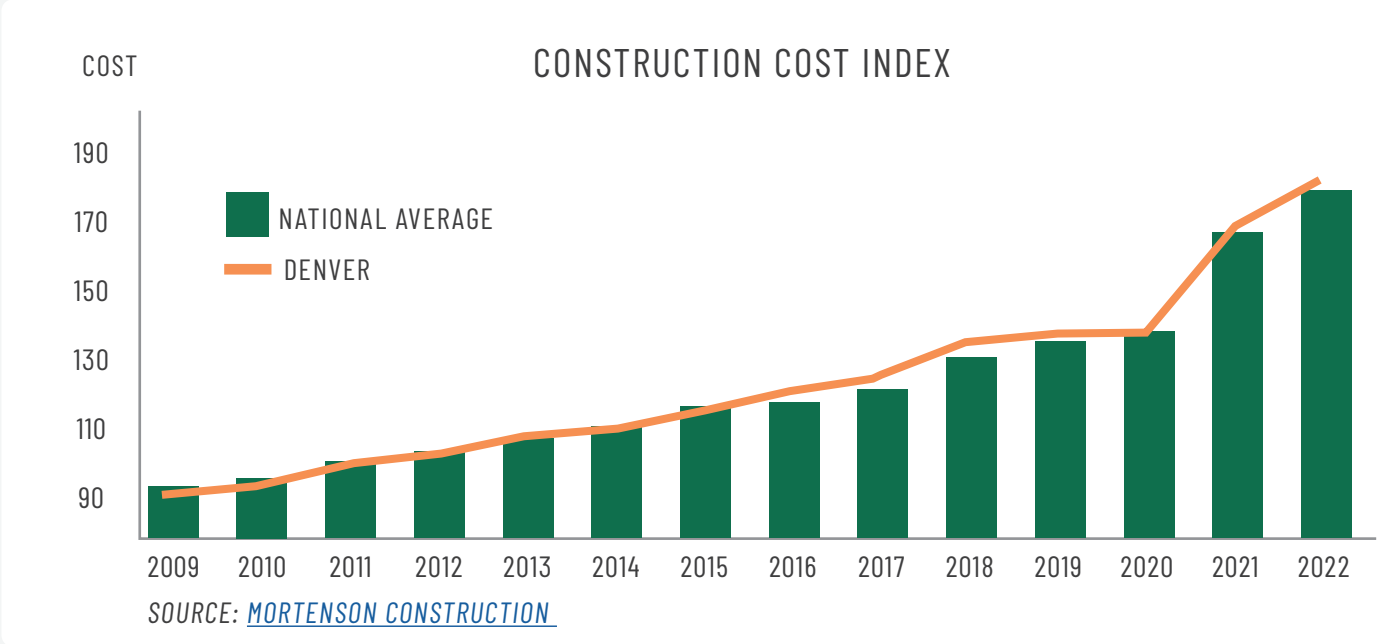
Using These Construction Costs

Throughout this report, differentiation is made between “total construction costs” and “net cost over business-as-usual fossil fuel systems”The distinction between the two is:

- Total costs: these are the total construction costs. This is the total amount of money that will need to be allocated for budgetary purposes.
- Net Cost: these are the total construction costs minus the replacement costs that would’ve been spent to replace the existing units with like-for-like fossil fuel units. These numbers represent the true cost of this decarbonization effort.

Note the numbers in the 2023 City Budget are budget numbers, and do not represent all costs for replacing the existing units. As such, they should not be used when determining the costs of decarbonization. In addition, the cost estimates in this report assume miscellaneous equipment (e.g. expansion tanks, domestic hot water storage tanks) need to be replaced. This assumption should be validated in detailed design, and could result in the total construction cost being lower if equipment can be reused.

As shown in the graph by the Mortenson, construction costs have been steadily rising since 2009. However, costs rose drastically from 2020 to 2022 (approximately 35%) due to global supply chain issues and unforeseen consequences of the COVID-19 pandemic.



Constructibility

Recent upheavals in the global supply chain and labor workforce have caused uncertainty in the construction market. Our construction teams are seeing the following trends as of March, 2023:

ELECTRICAL LEAD TIMES:

- Most commodity items, such as conduit, wire, fittings, etc. are readily available.
- Lead times for Switchboards are being quoted 50-80 weeks. Panel-boards can be 20-40 weeks depending on complexity.

MECHANICAL LEAD TIMES:

- Equipment needs to be ordered earlier in detailed design process to accommodate long lead times. Requires additional coordination earlier in design.

In order to combat these lead time challenges, design teams may need to be flexible with their specifications and the products/manufacturers they are selecting.

LABOR MARKET:

While we are seeing a general relaxing of labor shortages in other markets around the country, the contractor and labor shortages continue to persist in the Denver market.

Next Steps | Implementation

Implementation

A preliminary implementation timeline is shown below, based on the 2023 Capital Improvement Plan (CIP). Given the CIP replacement schedule, City Services will likely implement measures beyond 2030, at equipment end of life. The summary below is the implementation recommendation based on age of equipment as well as additional thoughts on emerging technologies and sequence of upgrades.

AIRSIDE

- As AHU-1 reaches end of life, replace with an ERV and water-source VRF system for the office area. Replace coil in AHU-2 for low-temp coil.
- Replace gas radiant tube heaters with electric unit heaters.

HYDRONIC

- As gas boilers reach end of life, replace with air-to-water heat pump on roof and backup electric boilers.
- Replace gas Vehicle Wash with electric.

RENEWABLES

- Install 220.3 kW-DC fixed-tilt ground-mounted solar PV system.

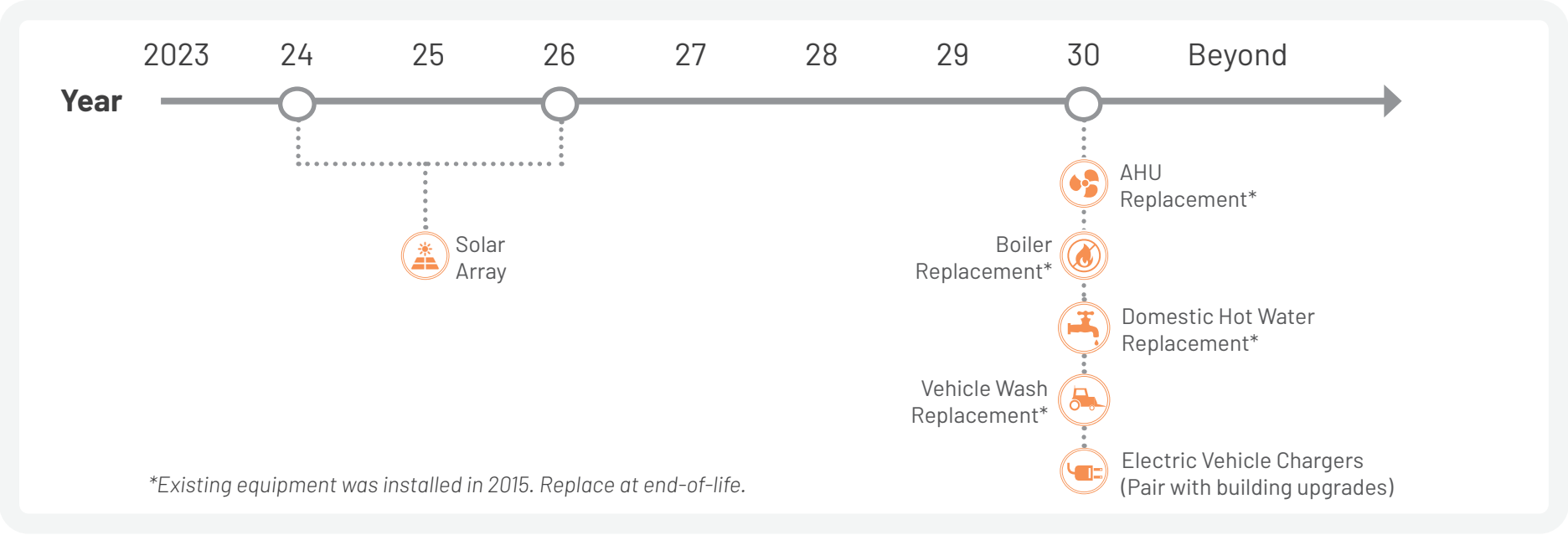
ELECTRIC VEHICLE CHARGER

- Provide 26 EV chargers for fleet and 2 EV chargers for public

DOMESTIC HOT WATER

- Replace gas water heater with electric.

Preliminary Implementation Timeline





Appendix

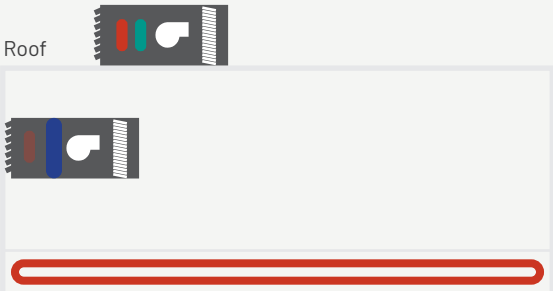
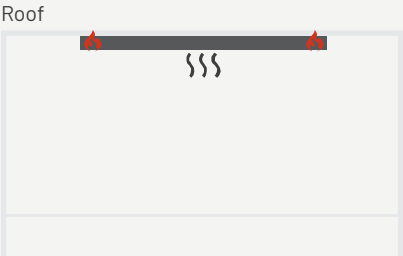
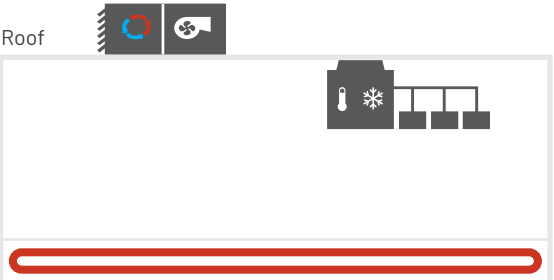
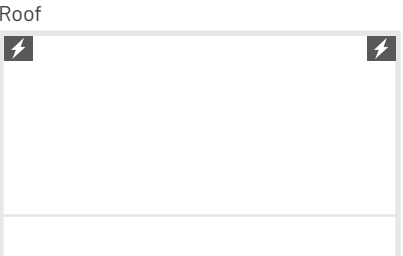
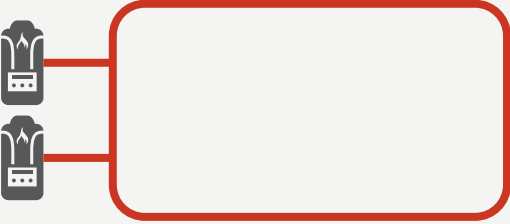
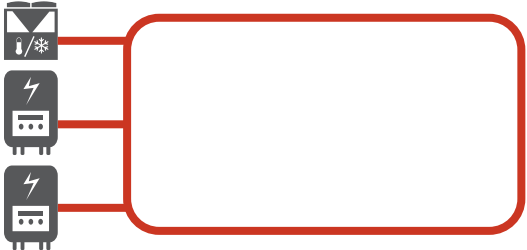
1. Mechanical System Matrix Options
2. Mechanical Decarbonization Scoping
3. Electrical Decarbonization Scoping
4. Structural Scoping (N/A for this Building)
5. Electric Vehicle Charging Narrative
6. Renewables Scoping
7. Cost Estimating



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HVAC System Matrix: City Services

	Admin/Ops: Existing System	Vehicle Storage: Existing System	Admin/Ops: Recommendation	Vehicle Storage: Recommendation
General	DX AHU, Evap Cool AHU, Gas-Fired Radiant Floor	Gas Tube Heaters	ERV+wVRF, HeatPump Radiant Floor	Electric Unit Heaters
				
Plant Equipment	Gas Boilers for Radiant Floor	-	Air-Water Heat Pump, Backup Electric Boilers	None
		-		None
Extent of Retrofit	-	-	Extensive Significant modifications and new infrastructure required to tie new ASHP and backup electric boilers into existing radiant loop. Brand new VRF system for office-side will also mean substantial retrofit.	Minimal Minor impact from replacing gas tube heaters with electric unit heaters.
Electrical Impacts	-	-	Upgrade Needed Mechanical electrification will require an electrical service upgrade. Existing diesel generator to remain.	Upgrade Needed Mechanical electrification will require an electrical service upgrade. Existing diesel generator to remain.
Limiting Factor	-	-	Existing Systems Constrained within design criteria of existing systems.	None
Verdict	-	-	Proceed w/ Detailed Scoping	Proceed w/ Detailed Scoping



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City Services – Mechanical Scope Narrative

Option 1 – Full Electrification

Demo Scope of Work:

- Includes removal and disposal of (1) AHU-1
 - Assumes cut, cap and make safe gas piping from AHU-1
- Includes removal and disposal of (14) fan-powered VAV boxes with hydronic reheat coils
- Includes removal and disposal of (1) high-temperature coil in AHU-2
- Includes removal and disposal of (2) gas-fired boilers
 - Includes removal of existing flues and patch and seal of roof
 - Assumes flues are accessible for demo, excludes demo/reinstalling of any shaft walls
 - Assumes cut, cap and make safe gas piping from each boiler
- Includes removal and disposal of (1) gas-fired domestic water heater
 - Includes removal of existing flues and patch and seal of roof
 - Assumes flue is accessible for demo, excludes demo/reinstalling of any shaft walls
 - Assumes cut, cap and make safe gas piping from unit
- Includes removal and disposal of (11) gas-fired radiant tube heaters
 - (8) located in vehicle storage building, (3) located in admin/ops building
 - Assumes cut, cap and make safe gas piping from vehicle wash
- Includes removal and disposal of (1) gas-fired vehicle wash
 - Assumes cut, cap and make safe gas piping from vehicle wash

New Scope of Work:

- Includes (3) new 30-ton modular air to water heat pumps on roof
 - Includes new piping to connect to existing building-wide condenser water loop as heat source
 - Located in approximately same area as existing AHU-1
 - Includes new curbs
 - Assumes existing ductwork and any sound attenuation to remain and be reused
 - Assumes any condensate off AWWHP may drain to existing roof receptors
- Includes (2) new 180kW electric boilers as backup to the new AWWHP
 - Assumes existing system pumps, expansion tank, and other accessories to remain
 - Assumes existing boiler piping connections to condenser water loop to be reused
- Includes new water-sourced VRF system for office side of admin/ops building
 - Includes (3) water-source condensing units for a total of 37-tons of system capacity
 - Includes new hydronic piping and valves to tie into condenser water loop
 - Includes new refrigerant suction/liquid piping between condensing units and branch controllers
 - Includes (2) 8-port branch controllers
 - Includes new refrigerant suction/liquid piping between branch controllers and terminal VRF cassettes
 - Includes (10) 2.5ton VRF cassettes and (4) 3ton VRF cassettes for space conditioning
 - Includes (14) 4" fan-powered VAV boxes for ventilation
 - Assumes existing MP ductwork between AHU and VAV boxes to remain and be reused
- Includes (1) new 2000 cfm ERV with heat wheel
 - Located in approximately same area as existing AHU-1



- Includes new supply and return ductwork to interior
 - Includes roof penetrations for new ductwork
 - Includes 15kW duct heater downstream of unit for additional capacity
- Includes (1) new low-temperature coil in AHU-2
- Includes (1) new 120 gallon, 45kW electric water heater
 - Assumes existing circulation pump, expansion tank, and other accessories to remain
 - Includes new relief piping
- Includes (8) new 5kW electric unit heaters, (32) new 7.5kW electric unit heaters, and (2) new 12.5kW electric unit heaters
 - (28) 7.5kW electric unit heaters and (2) 12.5kW electric unit heaters in vehicle storage
 - (8) 5kW electric unit heaters and (4) 7.5kW electric unit heaters in admin/ops
- Includes (1) new 5kW electric vehicle wash

Excludes any DHW circulation pumps and expansion tanks. Excludes any heating water pumps, ET, AS, and glycol feed systems. Excludes flue demolition up through roof; assumes cut/cap and abandon in place.

Mechanical General Inclusions, Clarifications, & Exclusions

- Includes allowance for crane/rigging
- Includes allowance for permits
- Includes allowance for carpentry
- Carrying Seattle labor rates
- Pricing in today's dollars
- Excludes temp HVAC and plumbing
- Excludes overtime work
- Excludes parking
- Excludes any new sound attenuation scope. Assumes ductwork and existing sound attenuation to remain.
- Excludes duct smoke detectors and wiring
- Excludes any heat tracing
- Excludes good faith survey
- Excludes demolishing gas distribution lines/piping back to meter
- Excludes condensate drain piping to roof drains. Assumes piping directly down onto roof.

LOUISVILLE CITY SERVICES - MECHANICAL PRICING DOCUMENT
OPTION 1 - FULL ELECTRIFICATION

EXISTING ADMIN BUILDING MECHANICAL DESIGN INCLUDES:
- RADIANT FLOOR FOR MAIN BUILDING, SERVED BY GAS BOILERS
- OFFICE: (1) AHU WITH HOT WATER HEATING AND DX COOLING, SERVING SERIES FPVAVS WITH HOT WATER REHEAT
- VEHICLE AREA: (1) AHU WITH HOT WATER HEATING, EVAP COOLING
- GAS-FIRED DOMESTIC WATER HEATER
- GAS-FIRED HOTSY VEHICLE WASHING BOILER

ADMIN/OPS BUILDING UPGRADE NARRATIVE:
-FULL ELECTRIFICATION OF THE ADMIN BUILDING BY REPLACING ALL GAS-FIRED EQUIPMENT WITH NEW ELECTRIC-ONLY EQUIPMENT; WILL REQUIRE AN ELECTRICAL SERVICE UPGRADE
-PROVIDE NEW AIR-TO-WATER HEAT PUMP AND TIE INTO EXISTING RADIANT SYSTEM FOR RADIANT FLOOR HEATING AND COOLING, WITH NEW ELECTRIC BOILERS FOR BACKUP HEAT

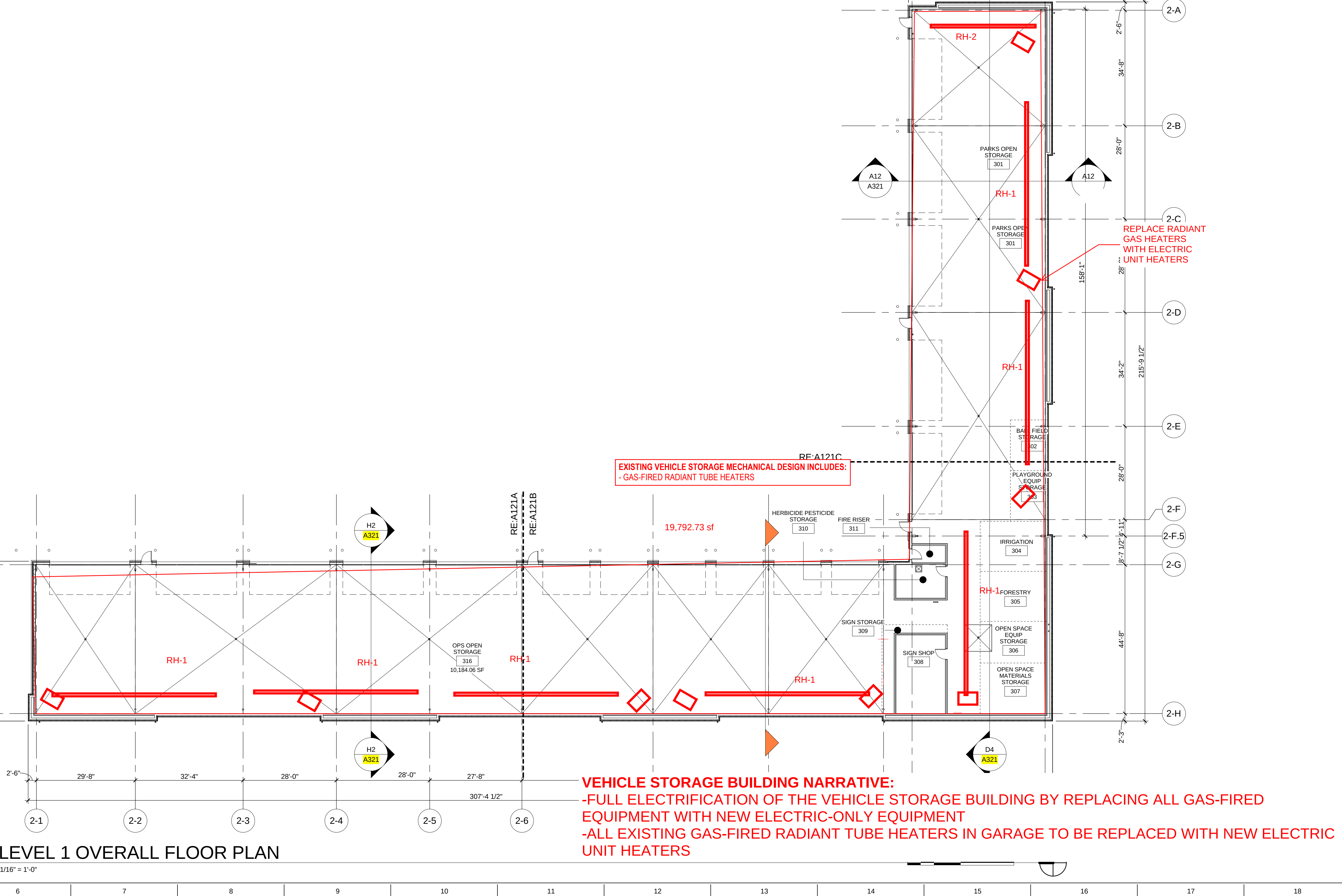
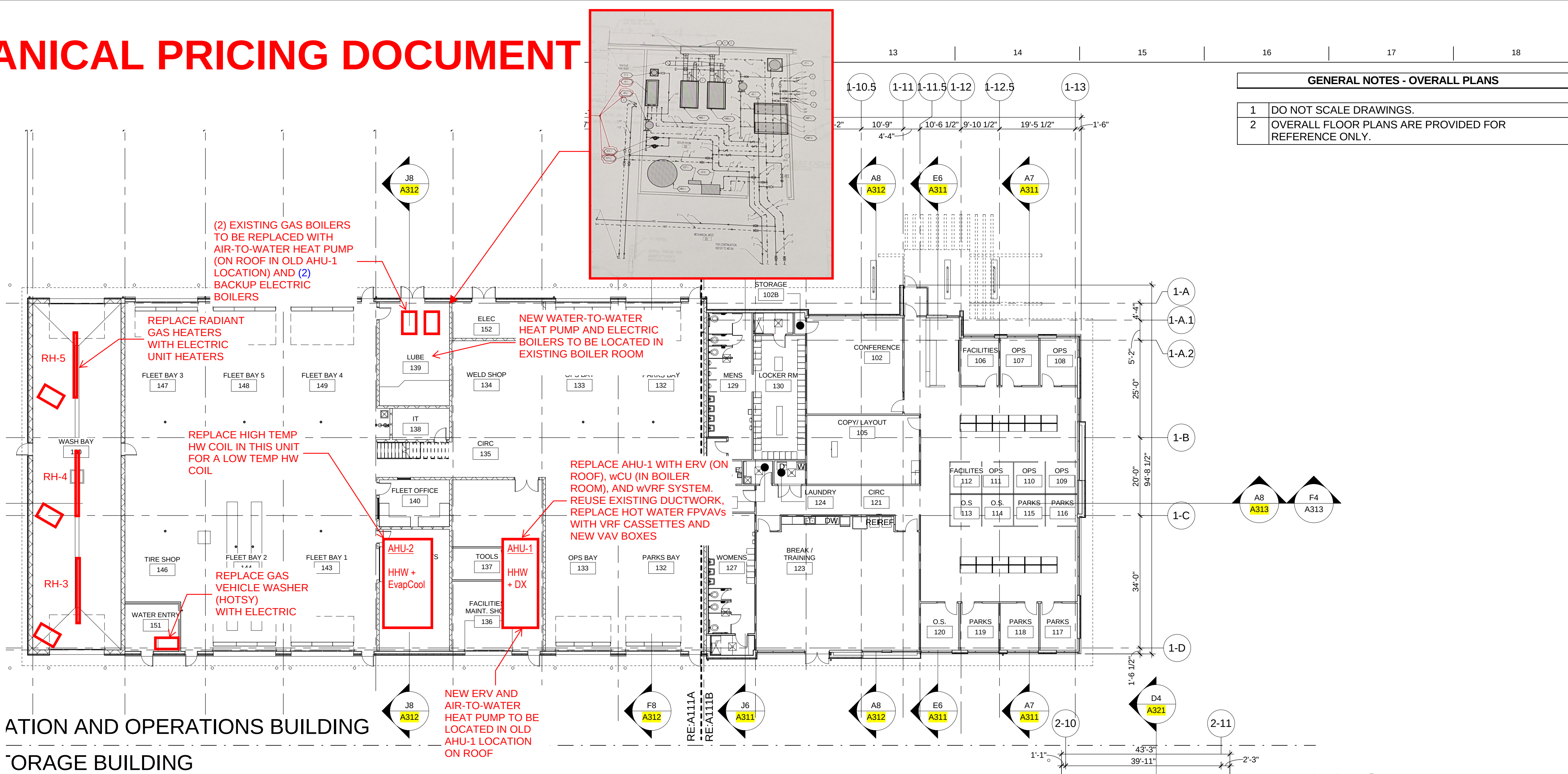
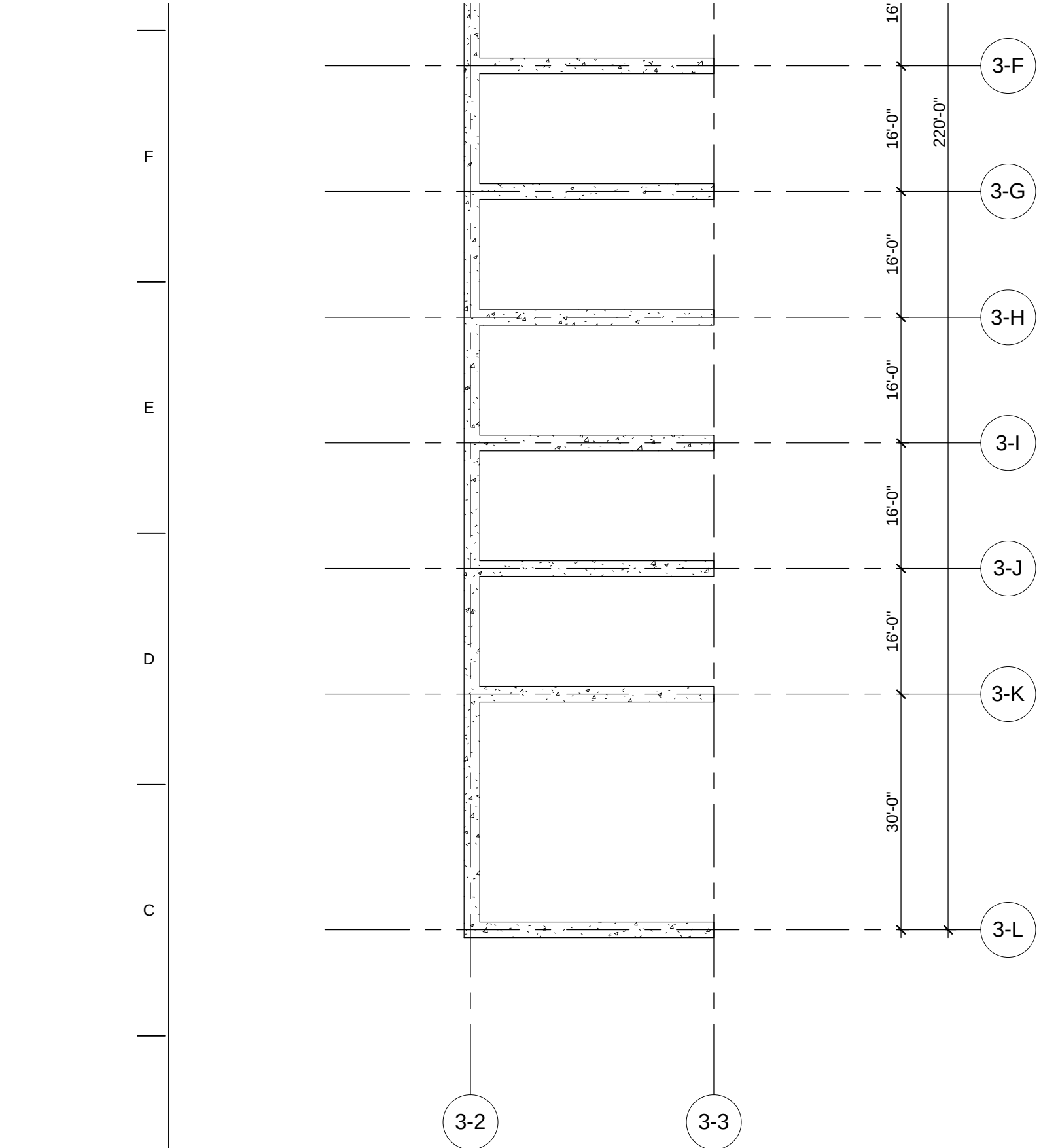
HEAT PUMP BASIS OF DESIGN:
(3) MULTISTACK ARP-030, OR SIMILAR 90-TON TOTAL HEAT PUMP CAPACITY
BOILER BASIS OF DESIGN:
(2) LAARS EB-180-480, OR SIMILAR 2000MBH CAPACITY FROM ELECTRIC BOILERS
-REPLACE EXISTING AHU-1 WITH NEW 2000 CFM ERV AND 37-TON WATER-SOURCE VRF SYSTEM, TIE INTO EXISTING HYDRONIC RADIANT FLOOR SYSTEM

ERV BASIS OF DESIGN:
(1) GREENHECK ECV-40-P-L, OR SIMILAR 2000CFM ERV/DOAS WITH HEAT RECOVERY
wVRF BASIS OF DESIGN:
(10) LG ARNU283TAA4, OR (10) SIMILAR 2.5TON VRF CASSETTES
(4) LG ARNU363TAA4, OR (4) SIMILAR 3TON VRF CASSETTES
(3) LG ARWM144BAS5, OR SIMILAR WATER-SOURCE CONDENSING UNITS FOR 37-TON SYSTEM CAPACITY
(2) LG PRHR083A, OR SIMILAR VRF BRANCH CONTROLLERS
(14) 4" TITUS DESV OR SIMILAR

-REPLACE EXISTING HIGH TEMPERATURE HOT WATER COIL IN AHU-2 WITH NEW LOW TEMPERATURE HOT WATER COIL
-REPLACE EXISTING GAS-FIRED RADIANT TUBE HEATER WITH NEW ELECTRIC RESISTANCE UNIT HEATERS

UNIT HEATER BASIS OF DESIGN:
(32) KING KB2007-1-PLTMX
(8) KING KB2005-1-PLTMX
(2) KING KB2012-1-PLTMX-FB
-REPLACE EXISTING GAS DOMESTIC WATER HEATER WITH NEW ELECTRIC WATER HEATER

EWB BASIS OF DESIGN:
(1) LOCHINVAR CHVX45-250
-REPLACE EXISTING GAS HOTSY WITH NEW ELECTRIC HOTSY
HOTSYS BASIS OF DESIGN:
(1) HOTSYS HWE-402009C



A5 LEVEL 1 OVERALL FLOOR PLAN
1/16" = 1'-0"

VEHICLE STORAGE BUILDING NARRATIVE:
-FULL ELECTRIFICATION OF THE VEHICLE STORAGE BUILDING BY REPLACING ALL GAS-FIRED EQUIPMENT WITH NEW ELECTRIC-ONLY EQUIPMENT
-ALL EXISTING GAS-FIRED RADIANT TUBE HEATERS IN GARAGE TO BE REPLACED WITH NEW ELECTRIC UNIT HEATERS

GENERAL NOTES - OVERALL PLANS	
1	DO NOT SCALE DRAWINGS.
2	OVERALL FLOOR PLANS ARE PROVIDED FOR REFERENCE ONLY.

RNL

1050 17TH STREET
SUITE A200
DENVER, CO 80265
303.295.1717 t
303.292.0845 f

CITY OF LOUISVILLE
LOUISVILLE CITY SERVICES
FACILITY

739 SOUTH 104TH STREET
LOUISVILLE, CO 80027

CIVIL/MARTIN / MARTIN
LANDSCAPE RNL
STRUCTURAL-HUITZ-ZOLARS
ARCHITECTURAL-RNL
EQUIPMENT MAINTENANCE DESIGN GROUP
PLUMBING-RMH GROUP
MECHANICAL-RMH GROUP
ELECTRICAL-RMH GROUP
ENERGY MODELING-AMBIENT ENERGY

1	ASI #1	11/12/2014
	CONSTRUCTION DOCUMENTS	09/12/2014
No	REVISION/SUBMISSION	DATE
PROJECT No: 3561.01		

OVERALL PLANS -
LEVEL 1

A101



Appendix

1. Mechanical System Matrix Options
2. Mechanical Decarbonization Scoping
3. Electrical Decarbonization Scoping
4. Structural Scoping (N/A for this Building)
5. Electric Vehicle Charging Narrative
6. Renewables Scoping
7. Cost Estimating

City Services – Electrical Scope Narrative

Option 1 – Full Electrification

- Electrical Demo:
 - Demolish existing CT metering cabinet
 - Demolish existing service conductors
 - Demolish existing utility transformer pad (upon completion of work)
- Electrical New Work:
 - Install new utility transformer pad, adjacent to existing, to allow for continuity of service. Precast or poured in place, per Xcel specification. Coordinate new installation details and location with Xcel energy.
 - Install new MSB 2000A NEMA 3R, per drawings
 - Include concrete equipment pad
 - Install utility meter base and 1” conduit to utility CT section
 - Install new 2000/3+ grounded service conductor from new utility transformer to new MSB. Allow for 100’. Restore concrete/asphalt.
 - Refeed existing 800A fused disconnect from new MSB. 800/4 feeder.
 - Provide new electrical distribution system, as shown in electrical sketches.
 - Incorporate replacement of heated storage building feeder conductors and circuit breakers (reuse existing conduit)
 - Provide feeders and hookups to equipment, as shown in electrical sketches.
 - Feeder lengths are indicated in electrical sketches

PV Array Electrical Infrastructure (Costs are included in Renewables report)

- Supply, install and circuit (qty 2) 500A visible break fused disconnects adjacent to the new MSB. As per drawings. All downstream PV scope is by others.

Level 2 & 3 EV Chargers and Supporting Infrastructure

- Provide new EV charging distribution and equipment as shown in electrical sketches:
 - Feeder lengths are indicated in electrical sketches.
 - (Qty 25 L2) 60A 208V dual port pedestal type EVSE’s. Zefnet-60-CPD or approved equivalent
 - (Qty 3 L3) pedestal type 50kW dual port EVSE’s. Tritium RTM-50 with 6m (19’) cable or approved equivalent.
 - Restore concrete / asphalt.

Electrical Exclusions

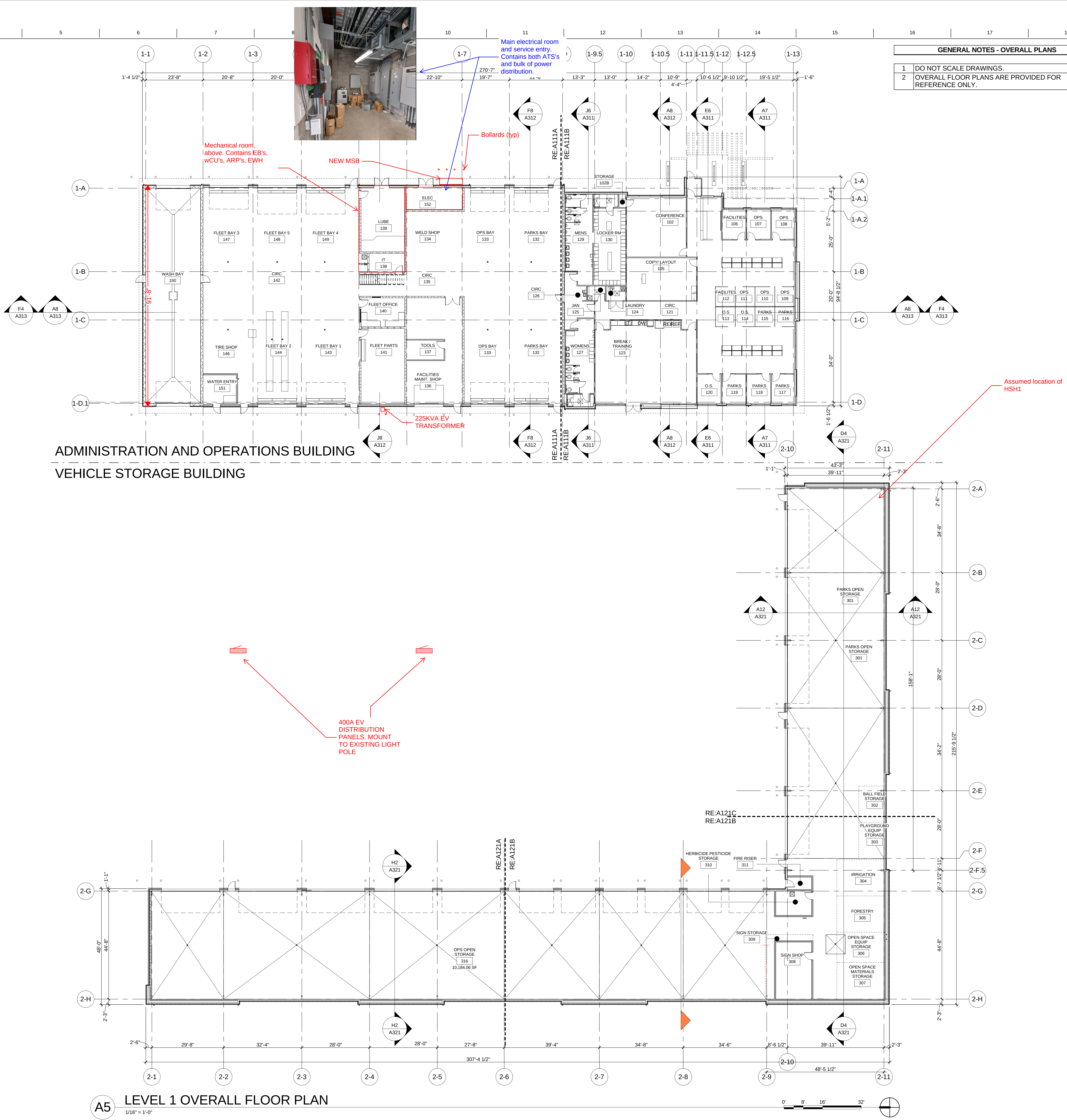
- Applicable sales, use and B&O tax
- Performance and Payment Bonds
- Utility company charges.
- Refurbishing existing lighting (cleaning, re-lamping, re-trimming, repair, restoration).



- Roof and building envelope penetrations, waterproofing.
- Moving, placing and (re)-calibrating owner equipment.
- Mechanical and plumbing control devices, including wiring, conduit, and components.
- Correcting existing code violations
- Hidden conditions.
- Removing, re-installing and replacing ceiling tiles.
- Opening and repairing walls and ceilings for electrical work.
- Patching and painting.
- Access panels.
- Temporary power and lighting
- Handling hazardous material including but not limited to asbestos, lead and PCB's.
- Overtime and shift premiums.
- Work stoppages, hindrances, multiple trim passes and out-of-sequence installation.
- Electrical engineering, calculations, drawings, peer review services.
- Structural and Seismic Engineering
- Material cost escalation.
- Plywood and specialty backing.
- Low voltage systems (telecom, CCTV, access control, audio visual, etc.).
- Any work not specifically included in this proposal.
- No thermostat relocations are included

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*REFER TO CIVIL SITE PLAN FOR
DIMENSION BETWEEN MAIN
BUILDING AND SALT STORAGE
STRUCTURE.



RNL

1050 17TH STREET
SUITE A200
DENVER, CO 80265
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CIVIL: MARTIN / MARTIN
LANDSCAPE: RNL
STRUCTURAL: HUITZ-ZOLARS
ARCHITECTURAL: RNL
EQUIPMENT MAINTENANCE DESIGN GROUP
PLUMBING: RNL GROUP
MECHANICAL: RNL GROUP
ELECTRICAL: RNL GROUP
ENERGY MODELING: AMBIENT ENERGY

CITY OF LOUISVILLE
LOUISVILLE CITY SERVICES
FACILITY

739 SOUTH 104TH STREET
LOUISVILLE, CO 80027

1	ASI #1	11/12/2014
B	CONSTRUCTION DOCUMENTS	09/12/2014
No.	REVISION/SUBMISSION	DATE
PROJECT No: 3561.01		

OVERALL PLANS -
LEVEL 1

A101

480 Volt - 120/208 Volt Transformer Sizes and Feeders											
Transformer Name	Load Served	NEC DEMAND LOAD KVA	KVA	Type	OC/P	Feeder	Primary	Feeder	Secondary	Feeder	Grounding Electrode
THP1	PANEL HSP1	75.0	75	DRY TYPE	125	125A3G	1-1/2" C - 3810, 1#6G	225	225A4BJ	2-1/2" C - 4840, 1#2G	#2
T1	PANEL P1A	75.0	75	DRY TYPE	125	125A3G	1-1/2" C - 3810, 1#6G	225	225A4BJ	2-1/2" C - 4840, 1#2G	#2
T2	PANEL P1B	75.0	75	DRY TYPE	125	125A3G	1-1/2" C - 3810, 1#6G	225	225A4BJ	2-1/2" C - 4840, 1#2G	#2
T3	PANEL P1A	75.0	75	DRY TYPE	125	125A3G	1-1/2" C - 3810, 1#6G	225	225A4BJ	2-1/2" C - 4840, 1#2G	#2

SHORT CIRCUIT SCHEDULE											
POINT	DESCRIPTION	Required Short Circuit (kA)	Short Circuit (kA)	Line-Line Voltage (V)	Length of Line (ft)	X/R Ratio	Rated kVA	X/R Ratio	Rated kVA	X/R Ratio	Rated kVA
X1	ESTIMATED 800 KVA TRANSFORMER	50,000	42,800	480	80	1.0	800	1.0	800	1.0	800
X2	UTILITY TRANSFORMER TO MAIN DISCONNECT	42,000	34,875	480	5	1.0	42,000	1.0	42,000	1.0	42,000
X3	MAIN DISCONNECT TO UTILITY METER	42,000	34,875	480	5	1.0	42,000	1.0	42,000	1.0	42,000
X4	UTILITY METER TO WIREWAY	42,000	32,071	480	5	1.0	42,000	1.0	42,000	1.0	42,000
X5	WIREWAY TO ATS-1 DISCONNECT	42,000	32,071	480	5	1.0	42,000	1.0	42,000	1.0	42,000
X6	ATS-1 DISCONNECT TO ATS-1	35,000	31,365	480	5	1.0	35,000	1.0	35,000	1.0	35,000
X7	ATS-1 TO PANEL MDPA	35,000	30,041	480	10	1.0	35,000	1.0	35,000	1.0	35,000
X8	PANEL MDPA TO PANEL HSH1	10,000	7,572	480	10	1.0	10,000	1.0	10,000	1.0	10,000
X9	HSH1 TO TRANSFORMER THP1	10,000	7,572	480	10	1.0	10,000	1.0	10,000	1.0	10,000
X10	THROUGH TRANSFORMER THP1	10,000	4,437	480	15	1.0	10,000	1.0	10,000	1.0	10,000
X11	TRANSFORMER THP1 TO PANEL HSP1	10,000	4,260	208	15	1.0	10,000	1.0	10,000	1.0	10,000
X12	PANEL MDPA TO PANEL L1A	22,000	19,130	480	20	1.0	22,000	1.0	22,000	1.0	22,000
X13	PANEL MDPA TO PANEL HMA	22,000	21,530	480	55	1.0	22,000	1.0	22,000	1.0	22,000
X14	PANEL MDPA TO TRANSFORMER T1	30,000	26,767	480	10	1.0	30,000	1.0	30,000	1.0	30,000
X15	THROUGH TRANSFORMER T1	10,000	5,426	480	15	1.0	10,000	1.0	10,000	1.0	10,000
X16	TRANSFORMER T1 TO PANEL P1A	10,000	5,268	208	10	1.0	10,000	1.0	10,000	1.0	10,000
X17	PANEL MDPA TO TRANSFORMER T3	20,000	17,377	480	60	1.0	20,000	1.0	20,000	1.0	20,000
X18	PANEL P1A TO PANEL P1A1	10,000	2,888	208	130	1.0	10,000	1.0	10,000	1.0	10,000
X19	WIREWAY TO ATS-2 DISCONNECT	42,000	32,071	480	5	1.0	42,000	1.0	42,000	1.0	42,000
X20	ATS-2 DISCONNECT TO ATS-2	35,000	31,365	480	5	1.0	35,000	1.0	35,000	1.0	35,000
X21	ATS-2 TO MDPB	30,000	27,174	480	25	1.0	30,000	1.0	30,000	1.0	30,000
X22	PANEL MDPB TO PANEL L1B	25,000	21,415	480	20	1.0	25,000	1.0	25,000	1.0	25,000
X23	PANEL MDPB TO PANEL HMB	22,000	18,267	480	75	1.0	22,000	1.0	22,000	1.0	22,000
X24	PANEL MDPB TO TRANSFORMER T2	20,000	17,070	480	10	1.0	20,000	1.0	20,000	1.0	20,000
X25	THROUGH TRANSFORMER T2	10,000	5,185	480	15	1.0	10,000	1.0	10,000	1.0	10,000
X26	TRANSFORMER T2 TO PANEL P1B	10,000	5,022	208	10	1.0	10,000	1.0	10,000	1.0	10,000
X27	PANEL P1B TO PANEL P1B1	10,000	3,858	208	65	1.0	10,000	1.0	10,000	1.0	10,000
X28	PANEL P1B TO PANEL P1B1	10,000	2,831	208	135	1.0	10,000	1.0	10,000	1.0	10,000
X29	AVAILABLE GENERATOR SHORT CIRCUIT	10,000	5,185	480	5	1.0	10,000	1.0	10,000	1.0	10,000
X30	THROUGH TRANSFORMER T3	10,000	5,107	208	5	1.0	10,000	1.0	10,000	1.0	10,000
X31	TRANSFORMER T3 TO PANEL P1A	10,000	5,107	208	5	1.0	10,000	1.0	10,000	1.0	10,000
X32	PANEL HSP1 TO PANEL HSP2	10,000	4,178	208	5	1.0	10,000	1.0	10,000	1.0	10,000

Notes:
1. CONTRACTOR IS RESPONSIBLE FOR ALL QUANTITIES, FEEDER ROUTING AND INSTALLATION. INDICATED FEEDER LENGTH WAS USED TO CALCULATE FAULT CURRENT AND IS AN APPROXIMATE QUANTITY. IF THE INSTALLED FEEDER LENGTH IS 10% SHORTER OR LONGER THAN THE INDICATED FEEDER LENGTH FAULT CURRENT MUST BE RE-EVALUATED AND REQUIRED BRACING RESIZED.

Existing 2" - 4#3/0, 1#6G.
Demo existing wire.
Retain conduit
2" - 3#4/0, 1#1/0N,
1#4G, 2#12
(230A)
180'

Connect to "UTIL" auxiliary contact.
Closed when ATS in UTIL,
open when ATS not in UTIL

Added load to MDPA 152.5kVA, 183A heater load
Requires 183A of distribution capacity.
Existing facility adjusted maximum demand (@1.25) is 132A. 132 + 183 = 315A < 400A rating. Submetering not required.

Added load to MDPB 162kVA, 195A continuous.
Requires 244A of distribution capacity.
Existing facility adjusted maximum demand (@1.25) is 132A. 132 + 244 = 376A < 400A rating. Submetering not required.

Added load to Generator is 162kW, 162kVA
Existing facility adjusted maximum demand is 79kW, assumed 100kVA.
Adjusting @1.25 gives 100kW / 124kVA.
Resultant generator load 262kW / 286kVA.
Existing generator is sufficient.

Refer to 2nd sketch for new scope.

ELECTRICAL ONE-LINE DIAGRAM

SCALE: NONE

SHEET NOTES

- POWER DISTRIBUTION SIZES ARE NOT INDICATED ON THIS DRAWING. CONTRACTOR SHALL ENSURE THAT ALL LUGS ARE SIZED TO HANDLE THE FEEDERS LISTED IN THE FEEDER SCHEDULE SHOWN ON THIS SHEET.
- ALL ELECTRICAL EQUIPMENT LOCATED OUTSIDE SHALL HAVE A NEMA 3R ENCLOSURE.

8x EUH circuits.
7 circuits with 4x EUH per circuit
1 circuit with 2x EUH
117.5kW total
141A continuous.

RNL

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RMH GROUP
engineering a greener future
MECHANICAL ELECTRICAL PLUMBING
10000 E. 1st Avenue, Suite 100
Denver, CO 80231
303 733 1000
FIRM JOB NUMBER

CIVIL: MARTIN / MARTIN
LANDSCAPE: RNL
STRUCTURAL: HITT-ZOLLARS
ARCHITECTURAL: RNL
EQUIPMENT: MAINTENANCE DESIGN GROUP
PLUMBING: RMH GROUP
MECHANICAL: RMH GROUP
ELECTRICAL: RMH GROUP
ENERGY MODELING: AMBIENT ENERGY

CITY OF LOUISVILLE
LOUISVILLE CITY SERVICES
FACILITY

739 SOUTH 104TH STREET
LOUISVILLE, CO 80027

CORE ELECTRIC INC.
AS-BUILT DRAWINGS
Sept 2015

NO.	REVISION/DESCRIPTION	DATE
3	ASI #9	01/15/2015
2	ASI #8	12/19/2014
1	ASI #1	11/12/2014
CONSTRUCTION DOCUMENTS		09/11/2014
REVISION/SUBMISSION		
DATE		
PROJECT No: 3561.01		

ELECTRICAL
ONE-LINE
DIAGRAM

E002

FEEDER SCHEDULE		
KEY	CONDUIT & CONDUCTORS [SEE NOTE 1]	REMARKS
60A4G	1-1/4" C - 4#4, 1#10G	
100A4G	2" C - 4#1, 1#6G	
125A3G	1-1/2" C - 3#1/0, 1#6G	
225A4BJ	2-1/2" C - 4#4/0, 1#2G	
400A4G	2-1/2" C - 4#4/0, 1#2G	NOTE 2
PAL400A4G	2-1/2" C - 4#4/0, 1#1G	NOTE 7.9
AL800A4G	3-1/2" C - 4#4/0, 1#3/0G	NOTE 8
AL800A4G	3-1/2" C - 4#4/0	NOTE 9
4G	3/4" C - 1#4G	
8G	3/4" C - 1#8G	
20G	3/4" C - 1#2/0G	
50A3G	1" C - 3#6, 1#10G	
100A4BJ	2" C - 4#1, 1#6G	NOTE 2
225A4G	2-1/2" C - 4#4/0, 1#4G	
200A4G	2" C - 4#3/0, 1#6G	
3/0G	3/4" C - 1#3/0G	

SCHEDULE NOTES:

- THIS FEEDER SCHEDULE IS BASED ON 60 DEGREE CENTIGRADE (TYPE THW) WIRE AND TERMINATIONS FOR SIZES #14 TO #1 AND 75 DEGREE CENTIGRADE (TYPE THHN/THWN) WIRE AND TERMINATIONS FOR SIZES #1/0 AND LARGER. UNLESS NOTED OTHERWISE, CONDUIT IS SIZED BASED ON TYPE EMT CONDUIT. USE OF OTHER CONDUIT TYPES REQUIRES RESIZING OF CONDUIT.
- FEEDERS MARKED WITH A "BJ" HAVE AN EQUIPMENT BONDING JUMPER. PROVIDE PROPERLY SIZED TERMINATIONS.
- FEEDER KEYS MARKED WITH A "P" ARE SIZED BASED ON TYPE SCHEDULE 40 PVC CONDUIT. USE OF OTHER CONDUIT TYPES REQUIRES RESIZING OF CONDUIT.
- FEEDERS MARKED WITH AN "AL" ARE ALUMINUM CONDUCTORS.

PROJECT:

CONSULTANTS:

REGISTRATION:

ISSUES:		
NO	DATE	DESCRIPTION

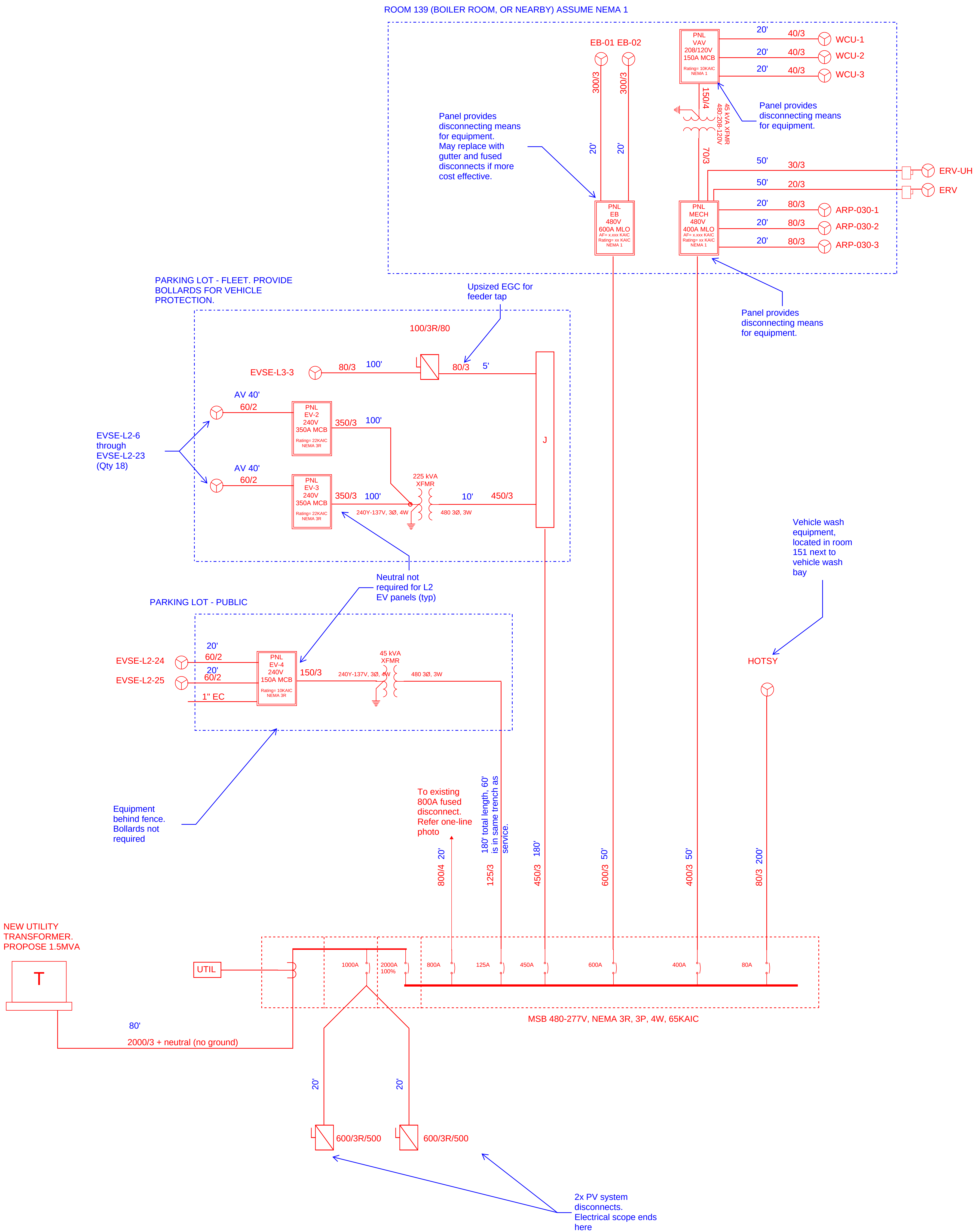
DESIGNED: DSG
DRAWN: DRW
CHECKED: CHK
JOB NO: PROJECT NUMBER

SHEET TITLE:

CITY SERVICES
NEW ONE-LINE

SHEET NUMBER:

ESK-02





Appendix

1. Mechanical System Matrix Options
2. Mechanical Decarbonization Scoping
3. Electrical Decarbonization Scoping
4. Structural Scoping (N/A for this Building)
5. Electric Vehicle Charging Narrative
6. Renewables Scoping
7. Cost Estimating



Appendix

1. Mechanical System Matrix Options
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City of Louisville
City Services
Electric Vehicle Charging Narrative

Electric Vehicle Charging Narrative

Electric Vehicle Charging Narrative

Fleet or EV Charging

As part of the decarbonization study, the fleet vehicles were analyzed for replacement with EV equivalents. In addition, building electrical capacities were reviewed to determine if they have enough capacity to charge the fleet vehicles and if any electrical upgrades may be needed to the buildings.

EV Fleet Conversion

Based on current technology, transitioning from internal combustion engine (ICE) vehicles to EVs can substantially lower overall carbon emissions. A caveat to consider in assessing the environmental impact of EVs is the variation of electricity generation sources in a given area. The state of Colorado relies mainly on coal and natural gas. However, the share of these fuel sources as a percentage of total generation is decreasing. Alternative energy sources such as wind and solar are increasing rapidly. By using additional onsite renewable energy sources and phasing in vehicle replacement it will be possible for Louisville's fleet to be entirely carbon free.

In the current vehicle market mainly light duty vehicles are being produced. The battery technology is still being developed for heavy-duty vehicles. The market is rapidly changing so over the course of the next 5 years new innovation should allow heavy duty vehicles to be carbon free through either advanced battery technology or other yet to be determined technology.

EVs typically have a higher initial capital cost to purchase or lease when compared to ICE vehicles, EVs can cost less in the long-term due to lower fuel costs, different maintenance requirements, and longer vehicle lives. Therefore, it is important to consider the entire lifespan of a vehicle when investing in fleet vehicles. There are also limiting factors of EVs to consider, such as range and power needs of certain fleet vehicles, as well as the near-constant changes in the electric vehicle and infrastructure technology.

Charging Infrastructure

When planning for EV charging infrastructure, it is recommended to proactively plan for the number of charging stations needed by installing more electrical equipment (e.g. transformers and conduits) than is needed for the initial purchase of EVs. It is more cost effective to install excess electrical equipment during the initial installation than having to add electrical wires each time additional stations are required. This electrical equipment installation does not include purchasing all the charging stations that can fit with that equipment, but instead having the electrical capacity to purchase charging stations to meet future capacity needs without additional construction. The city has already thought about this and this report is the result of that forward thinking.

While there are three levels of EV charging infrastructure currently available, Level 2 charging is currently the most prevalent among them and requires electrical infrastructure upgrades to extend 240 volt AC service to locations where the EVs would charge. It charges at over twice the rate of level 1, adding 12 to 80 miles of range per hour charging. Level 3 charges are also becoming more common and can add from 80 to 500 miles of range per hour. Level 3 charging typically requires a 480 volt AC service. The level 2 and 3 chargers with the increased rate of charging can justify the costs to serve the needs of fleet management in a timely manner. Costs per unit can vary within these ranges depending on the installation and labor costs, warranties for equipment, and operation and maintenance costs for the equipment. Level 2 chargers provide 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.

Electric Vehicle Charging Narrative

For the public chargers the City may want to consider charging a some type of fee for usage. Many charging stations charge a usage fee at some dollar per kWh of charging. This can help offset the peak demand that may be incurred by the city. Another option is to charge an idle fee. This type of fee encourages people not to leave there vehicle plugged in for long period of times once the vehicle has reached full charge.

Another consideration for charging infrastructure is the daily charging schedule. Most of the buildings reviewed for this study are on a secondary general rate schedule. This rate schedule does not have time of use rates for electrical consumption or peak demand. This means depending on when and how many vehicles charge relative to the buildings peak demand, it may increase the demand charges the city pays. Xcel Energy does offer a EV charging rate plan that incentivize the intentional reduction of electricity use during peak energy demand periods, such as during hot summer days. This rate plane does require a separate service for just the charging stations. Planning for fleet recharging during off-peak periods can add up to thousands of dollars in savings.

Battery capacity

Battery technology is changing rapidly, resulting in increased charge capacity and lower operating cost per mile. Many manufactures now offer eight year/100,000 mile warranties on their EV batteries (generally covering defects and workmanship), and some offers an eight year/100,000 mile warranty on battery capacity. Auto manufacturer warranties and charge capacity have generally reduced consumer concern about battery life and range. As a result, the analysis of total ownership cost does not account for the cost of EV battery replacement, assuming that municipal vehicles will be retired at the warranty expiration.

City Services Site

City services is where the majority of the cities fleet is stored. There are ~71 vehicles that are stored at this site. Most are considered heavy-duty vehicles. These vehicles are primarily used around the city for maintaining the parks, buildings, and roads. See table XX below.

Department	Make	Model	Total
Building Inspection	Ford	Escape	2
		F150	1
Code Enforcement	Chevy	Colorado	1
	Dodge	Dakota	1
Engineering	Chevy	Colorado	2
	Ford	Expedition	2
Facilities	Chevy	Colorado Silverado 3/4 4X4	1
			1
	Ford	F150	1
	Honda	Civic	1
Parks	CHEVROLET	Colorado	1
	Chevy	1500	1
		2500	2
		Colorado Silverado 3/4 4X4	10
			3
	Dodge	Dakota	2
	Ford	F250	2
		F350	4
		F550	1

Electric Vehicle Charging Narrative

		F750	1
	GMC	3500	1
	Toyota	Tacoma	1
	Ford	E350	1
Streets		Silverado 3/4 4X4	1
	Ford	F550	2
	International	7400	3
		HV 513 6x4	1
	John Deere	624K	1
		624I	1
	Ram	2500	1
Utilities	Tymco	600BAH	1
	CHEVROLET	2500	1
	Chevy	Colorado	1
		Silverado 3/4 4X4	1
	Dodge	2500	1
	Ford	F150	1
		F250	1
		F450	1
		F550	1
	International	7400	1
		7400	1
		MV607	1
	John Deere	410J	1
		410L	1
	Ram	2500	4
Total			71

We recommend install 26 dual head chargers and upgrading the electrical infrastructure to support them. This number of chargers does not result in every vehicle being able to charge at once because there are several vehicles that have seasonal use.

Most of these vehicles are consider heavy duty and currently there is no direct replacement for these types. It is anticipated those vehicles will be available in the next 5 to 10 years. We also recommend installing publicly available chargers for the city residents. Table XX below shows the number of recommended chargers.

Existing Public charging stations	Existing Public Charger Level	Quantity of New Level 2 Public Charger	Quantity of New Level 3 Public Charger	Quantity of New Level 2 Fleet Charger	Quantity of New Level 3 fleet Charger
0	N/A	2	0	23	3



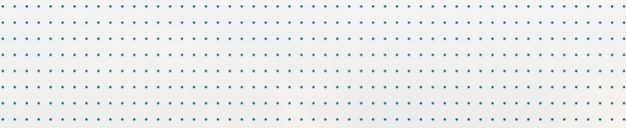
Electric Vehicle Charging Narrative

The quantity of public chargers selected for this site was based on the remaining parking spots located in that parking strip area and proximity to the electrical services that will be in the area for the fleet chargers. More or less spots could be installed or located in other areas but this will affect the cost.



Appendix

1. Mechanical System Matrix Options
2. Mechanical Decarbonization Scoping
3. Electrical Decarbonization Scoping
4. Structural Scoping (N/A for this Building)
5. Electric Vehicle Charging Narrative
6. Renewables Scoping
7. Cost Estimating



City of Louisville Decarbonization Study

Louisville City Services

RENEWABLES SUPPORTING ANALYSIS

LOUISVILLE, CO

AUGUST 18, 2023

Together Building a Thriving Planet



Louisville City Services

The Louisville City Services is a great candidate for a ground mounted solar PV system. Just South of the buildings on site there is room to install a ground mounted system. The economics of the utility savings makes the system advantageous to the City of Louisville's Decarbonization Plan.

1. Proposed Solar PV System Overview

Below is a high-level summary of the proposed system specifications. Please note, specific equipment manufacturers and models may change depending on availability and market conditions at the time of construction.

SITE NAME	SITE ADDRESS	SIZE (KW-DC)	SIZE (KW-AC)	SYSTEM TYPE	YEAR 1 PRODUCTION (kWh)
Louisville City Services	739 S 104th St, Louisville, CO 80027	220.3	180	Ground Mount	371,759



Louisville City Services

LOUISVILLE CITY SERVICES EQUIPMENT AND QUANTITY SUMMARY

QUANTITY	EQUIPMENT DESCRIPTION
408	JA Solar, JAM72D30-540 (540W) – Bifacial Mono PERC Half Cell Double Glass Modules
3	CPS SCA60KTL-DO/US-480 - Inverters
1	30° Fixed-Tilt Ground Mount Racking System
1	AlsoEnergy Data Acquisition System (DAS) Package – PLCS400
1	Electrical Balance of Systems Package

AlsoEnergy Data Acquisition System (DAS) includes the equipment/functionality listed below.

- NEMA 4 Enclosure and Data Logger
- Cellular modem
- CT Based Revenue Grade Meter
- Inverter Direct Monitoring
- 5-year service plan
- A Meteorological Station consisting of the following:
 - Cell Temp Sensor
 - Pyranometer
- Publicly accessible web-based dashboard functionality

The Electrical Balance of Systems Package includes all components to create an electrically complete solar PV carport installation. This includes grounding materials, wiring, conduit, MCT, panelboards/combiners, switchgear, fuses, and disconnects.

2. Production Modeling

Array layouts and system production are modeled in Helioscope, an industry-standard design and energy modeling software package with 3-dimensional modeling capabilities. Through Helioscope, we can incorporate site-specific characteristics of buildings and shade producing obstructions to determine their impacts upon system layout and production. McKinstry further applies our knowledge of codes and regulations, industry best practices, and professional judgment to ensure that designs are code-compliant and strike a balance across customer preferences, production, constructability, and price concerns.

Helioscope provides robust PV system output modeling capabilities. We use these in conjunction with Typical Meteorological Year (TMY) weather datasets, real-world equipment specifications, proprietary 3rd-party-engineered dust and snow soiling models, and professional judgment to determine a system's annual kWh production. For City of Louisville, we are using the TMY, DENVER INTL AP, NSRDB (tmy3,l) weather data set and soiling conditions from the DNV-GL NOAA Lafayette station. Annual production is estimated at 371,759kWh. Full Helioscope report below.

Louisville City Services



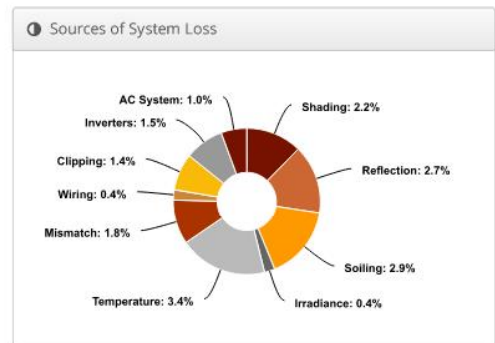
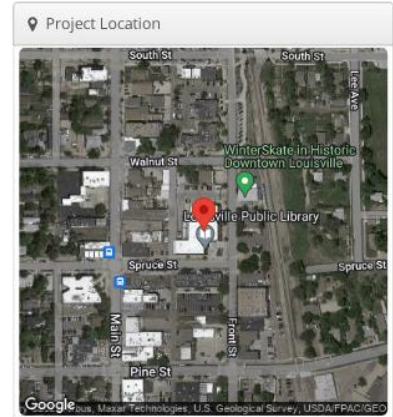
Annual Production Report produced by Mountain Bryan H

Cohort 3 - City Services City of Louisville, 951 Spruce St, Louisville, CO 80027

Report

Project Name	City of Louisville
Project Address	951 Spruce St, Louisville, CO 80027
Prepared By	Mountain Bryan H bryanh@mckinstry.com

System Metrics	
Design	Cohort 3 - City Services
Module DC Nameplate	220.3 kW
Inverter AC Nameplate	180.0 kW Load Ratio: 1.22
Annual Production	371.8 MWh
Performance Ratio	84.7%
kWh/kWp	1,687.4
Weather Dataset	TMY, DENVER INTL AP, NSRDB (tmy3, l)
Simulator Version	f1afba56bc-0d48734f56-22c03a577b-429aea41ae



Louisville City Services



Annual Production Report produced by Mountain Bryan H

⚡ Annual Production			
	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,670.2	
	POA Irradiance	1,993.2	19.3%
	Shaded Irradiance	1,949.9	-2.2%
	Irradiance after Reflection	1,897.5	-2.7%
	Irradiance after Soiling	1,842.5	-2.9%
	Total Collector Irradiance	1,842.5	0.0%
Energy (kWh)	Nameplate	411,061.7	
	Output at Irradiance Levels	409,391.2	-0.4%
	Output at Cell Temperature Derate	395,362.3	-3.4%
	Output After Mismatch	388,408.6	-1.8%
	Optimal DC Output	386,855.0	-0.4%
	Constrained DC Output	381,317.3	-1.4%
	Inverter Output	375,514.7	-1.5%
	Energy to Grid	371,759.5	-1.0%
Temperature Metrics			
	Avg. Operating Ambient Temp	15.0 °C	
	Avg. Operating Cell Temp	25.0 °C	
Simulation Metrics			
	Operating Hours	4513	
	Solved Hours	4513	

☁ Condition Set												
Description	Carport 5 degrees											
Weather Dataset	TMY, DENVER INTL AP, NSRDB (tmy3,I)											
Solar Angle Location	Project Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Diffusion Model											
Temperature Model Parameters	Rack Type						U _{const}			U _{wind}		
	Fixed Tilt						29			0		
	Flush Mount						15			0		
	East-West						29			0		
	Carport						29			0		
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	6	6	5	4	1	0	1	1	2	2	4	8
Irradiation Variance	3.5%											
Cell Temperature Spread	3° C											
Module Binning Range	0% to 2.5%											
AC System Derate	1.00%											
Trackers	Maximum Angle							Backtracking				
	60°							Enabled				
Module Characterizations	Module					Uploaded By		Characterization				
	JKM405M-72HL-V (Jinko Solar)					HelioScope		Spec Sheet Characterization, PAN				
	JAM72D30-540/MB (JA Solar)					HelioScope		Spec Sheet Characterization, PAN				
Component Characterizations	Device						Uploaded By		Characterization			
	CPS SCA50KTL-DO/480 (Chint)						HelioScope		Spec Sheet			
	CPS SCA60KTL-DO/480 (Chint)						HelioScope		Spec Sheet			
	CPS SCH100KTL-DO/US-480 (Chint Power Systems)						McKinstry Solar		Default Characterization			

📦 Components		
Component	Name	Count
Inverters	CPS SCA60KTL-DO/480 (Chint)	3 (180.0 kW)
Strings	10 AWG (Copper)	24 (4,723.7 ft)
Module	JA Solar, JAM72D30-540/MB (540W)	408 (220.3 kW)

Louisville City Services

3. Annual Utility Savings and Value of Solar Energy

To analyze utility bill savings, we utilize Energy Toolbase, an industry-standard bill modeling software package. Energy Toolbase estimates bill savings based upon a site's electric load characteristics, PV system production (imported from Helioscope or other sources), and local utility tariffs and net metering policies. Xcel Energy tariffs and Net Metering tariff adjustments used in this analysis are:

- Secondary General (SG)
- Secondary Photovoltaic Time-of-Use (SPVTOU)
- Net Metering Service (Schedule NM)

To properly calculate the annual utility savings associated with the solar PV, we need to analyze the building load after all electrification and carbon reduction measures are implemented. As noted in the Summary Report, there is one bundles of measures – Bundle 1 (Full Electrification). For this site we've included a Bundle 2 (Existing Conditions) to show the value of the solar system pre-electrification measures. Each create a slightly different building load baseline. Therefore, all scenarios are listed below. Baseline utility year is 2019 and the assumed DOE building profile is Medium Office which models a daytime usage more closely representing the hours of the City Services meter.

OPTION 1 - GROUND MOUNT ONLY ESTIMATE WITH SPVTOU RATE SWITCH

SCENARIO	ANNUAL SAVINGS	ENERGY SAVINGS	DEMAND SAVINGS
Bundle 1	\$42,815	\$15,413	\$27,402
Bundle 2	\$26,308	\$17,104	\$9,204

All Bundles are modeled with a rate switch to SPVTOU. To qualify for a rate switch to SPVTOU, the building must have a minimum 30% load factor for the trailing 12 months and less than 500kW service demand. The average existing load factor for this site is around 50%, and the service demand is below 500kW.

4. System Price and Financial Results

There are two main avenues City of Louisville can choose to finance these projects – cash purchase or tax-exempt lease purchase (TELP). As a tax-exempt entity, City of Louisville is eligible for direct pay in Year 1 at Energy Investment Tax Credit (ITC) rates. These rates are 30% for cash purchase and 25.5% for TELP.

At this early feasibility study stage of a portfolio, we focus on simple payback to get a high-level look at the project economics. Our simple payback calculation is based on Year 1 solar production, Year 1 annual utility savings, and the Solar*Rewards C&I incentive program. Should any of these projects move into the next stage of development, McKinstry would develop more detailed proformas and cash flows to include items like solar degradation, Operations & Maintenance, discount rates, and more.

McKinstry aims to recommend solar systems that will pay back in the system lifetime, between 25-30 years. In all funding scenarios, this system would pay back within the solar lifetime.

Louisville City Services

BUNDLE 1 FULL ELECTRIFICATION	SYSTEM PRICE	ANNUAL SAVINGS	UTILITY INCENTIVE	SIMPLE PAYBACK (YRS)
Cash Purchase or Tax-Exempt Lease Purchase (TELP)	\$865,000	\$42,815	\$13,820	15.3
TELP with IRA	\$644,425			11.42
Cash Purchase with IRA	\$605,500			10.73
BUNDLE 2 EXISTING LOADS	SYSTEM PRICE	ANNUAL SAVINGS	UTILITY INCENTIVE	SIMPLE PAYBACK (YRS)
Cash Purchase or Tax-Exempt Lease Purchase (TELP)	\$865,000	\$26,308	\$13,820	21.7
TELP with IRA	\$644,425			16.16
Cash Purchase with IRA	\$605,500			15.19

Please note that there is a proposed service upgrade for this site associated with Bundle 1. The cost of that upgrade is included in the Electrification scope of work. The full PV scope from the Point of Interconnection, to the Solar Disconnect, Solar Meter, AC Combiner, Inverters to Modules is included in the pricing below. Additionally, pricing below assumes Louisville moves forward with a system at the Golf Clubhouse and City Hall; there are cost efficiencies in material, installation, and construction management scopes using a portfolio approach.

Another metric that may be useful as the City of Louisville considers the best way to decarbonize is levelized cost of electricity (LCOE). This is defined as capital cost divided by the estimated system lifetime production with units of \$/kWh. It can help the City of Louisville compare the value of owning onsite solar versus subscribing to renewable utility programs like Renewable Connect and Windsource. The table below shows LCOE with and without the Solar*Rewards C&I incentive.

BUNDLES 1-2	LCOE - NO UTILITY INCENTIVES (\$/KWH)	LCOE - W/ UTILITY INCENTIVES (\$/KWH)
Cash Purchase or Tax-Exempt Lease Purchase (TELP)	\$0.078	\$0.062
TELP with IRA	\$0.070	\$0.038
Cash Purchase with IRA	\$0.066	\$0.034

Louisville City Services

5. Future Considerations and Next Steps

Should Louisville decide to move forward with the City Services PV system, next steps would involve a geotechnical study, utility locates, land survey, racking and electrical bid sets, an interconnection application to Xcel, a subcontractor RFP to get final pricing, and any other due diligence items necessary to de-risk the project and ready it for implementation.

Assumptions, Inclusions, and Exclusions

- Codes and Utility Standards:
 - NEC 2020
 - IBC 2018
 - IFC 2018
 - Xcel Energy Blue Book (7/31/2022 Version)
 - Xcel Energy DG Tech Manual (10/28/2021 Version)
- Tax-exempt
- Prevailing wage
- Geotechnical Analysis allows for standard pile driven piles.
- No hazardous soils or materials (asbestos, PFAS, etc.). Should monitoring, mitigation, abatement, and/or disposal be required, Louisville would be responsible for this additional scope.
- The provided financial model projects that this site will qualify for SPVTOU rate class as its existing Load factor is around 50% (30% is the minimum required amount) and site demand is below 500kW.
- Pricing assumes a portfolio approach; Louisville will move forward with a solar PV system at both the Golf Clubhouse and City Hall.
- Pricing includes payment & performance bond
- Terms & Conditions listed in the Xcel Energy Interconnection Agreement
- Current labor rates
- Modeling:
 - TMY, DENVER INTL AP, NSRDB (tmy3,l) weather file
 - Soiling data from DNV-GL
- Design Loads
 - Wind speed:
 - Risk Category II: 145mph
 - Exposure: C
 - Ground snow load: 30 psf
 - Risk Category II: 1.0 importance factor
- No interconnection upgrade costs
- No grounding transformers
- Major equipment warranties
 - Modules – 12 year Product
 - Modules – 30 year Power Output
 - Inverters – 10 years
 - DAS – 5 years
 - AC Combiners – 5 years
 - LEDs – 5 years
- No extended warranties
- No ongoing DAS Costs

Louisville City Services

- Any ongoing fees beyond year 5 are excluded (both Cell Service and Data Subscription Monitoring fees).
- No backup generation
- Xcel Energy Solar*Rewards C&I Incentives: Tier 1: <250kWac = \$0.04/kWh for 20 years



Appendix

1. Mechanical System Matrix Options
2. Mechanical Decarbonization Scoping
3. Electrical Decarbonization Scoping
4. Structural Scoping (N/A for this Building)
5. Electric Vehicle Charging Narrative
6. Renewables Scoping
7. Cost Estimating

City Services Cost Estimates

Three sets of numbers are listed below:

1. Cost Delta of Decarbonization – These are the total construction costs minus the replacement costs that would've been spent to replace the existing units with like-for-like fossil fuel units. These numbers represent the true cost of this decarbonization effort.
2. Total Decarbonization Construction Costs – These are the total amounts of money that will need to be allocated for budgetary purposes. The delta between the above numbers and the below numbers represents the cost of decarbonization.
3. Baseline Costs - These are the costs that would be spent to replace the existing gas-based systems with like-for-like gas units.

All numbers are “all-in costs”, including all GC markups, permitting, etc. They are also Rough Order of Magnitude (ROM) numbers, with a +/-20% range. See the “Construction Pricing Context” section in the report body for more detail. All costs associated with the solar PV systems (including the electrical infrastructure to support these systems) are included in the Renewables costs as outlined in a separate section of the Appendix.

Cost Delta of Decarbonization

Decarbonization Delta Costs

City Services

Scope	Total Cost
Option 1 (Full Electrification)	\$ 1,173,516

Total Decarbonization Construction Costs

Option 1 (Full Electrification)

City Services

Scope	Total Cost
HVAC Ductwork	\$ 403,000
HVAC Piping	\$ 1,635,000
Plumbing	\$ 63,000
Electrical	\$ 1,035,000
Structural	\$ -
Total:	\$ 3,136,000

Electric Vehicle Charging

City Services

Scope	Total Cost
EV Charging	\$ 1,257,000



Baseline Costs

Gas Like-for-Like Replacement City Services

Scope	Total Cost
Option 1 (Full Electrification)	\$ 1,962,484