Electric Vehicle Charging Infrastructure Costing Study

Electrical Engineering Services

Prepared for:
Clean Air Partnership

AUTHORED BY:
Brendan McEwen, MCP; Tara Katamay-Smith, EIT, M.Sc. & Trevor Egan, EIT, B.A.Sc.

PEER REVIEWED BY:
Peter Lee, P. Eng, Mulvey & Banani International Inc.

Submitted by:
AES Engineering
505 Burrard Street, Suite 950 – Box91
Vancouver, BC, Canada
V7X 1M4
P: 604 569 6500
F: 604 569 6501
aesengr.com

Project No.: 2-21-050
Date: 10/13/2021

DESIGNING A BETTER TOMORROW

Table of Contents

About This Report

The Clean Air Partnership, with funding from The Atmospheric Fund, is supporting local governments in the Greater Toronto Hamilton Area (GTHA) to adopt “EV Ready” requirements for new residential developments.

The Clean Air Partnership commissioned this *Electric Vehicle Charging Infrastructure Costing Study* to inform local governments, developers, electrical designers, utilities, and other stakeholders, about the costs of making parking in new construction EV Ready, and the design strategies that can help minimize these costs. This report provides background information relating to EV Ready requirements; summarizes 100% EV Ready design options and costing analysis for four residential building archetypes common to the GTHA; and makes recommendations for EV Ready residential parking for GTHA local governments.

This report was prepared by AES Engineering Ltd., an electrical engineering firm that has assisted multiple Canadian local governments in developing EV Ready requirements. AES partnered with Mulvey + Banani International Inc (MBII), a Toronto-based electrical engineering consulting firm. MBII provided Ontario electrical design expertise, and peer reviewed design and costing assumptions.

Summary

Electric vehicle (EV) adoption is growing rapidly, and near total replacement of passenger vehicles with EVs will be required to achieve local and Federal government climate targets. Providing access to "at home" EV charging is a critical factor to ensure that households will choose EVs. Accordingly, local governments are increasingly requiring 100% "EV Ready" residential parking in new developments. EV Ready parking is defined as a parking stall that has an adjacent energized outlet (i.e. an electrical junction box or a receptacle) at which an EV supply equipment (EVSE – i.e. an EV charger) can be installed in the future.

This *Electric Vehicle Charging Infrastructure Costing Study* summarizes design options and costing analysis for four residential development archetypes to comply with 100% EV Ready residential parking requirements. Table ES-1 summarizes the archetypes.

Table ES-1: Overview of parking for each archetype.

				Parking Stalls	
#	Archetype	Storeys	Number of Units	Resident	Visitor
1	High-Rise	16	405	369	61
2	Mid-Rise	7	151	119	38
3	Townhouse	3	19	38	5
4	Single Family	3	22	44	7

For each archetype, a range of different electrical design scenarios were developed. These scenarios included those:

- Complying with the Toronto Green Standard version 3 (TGSv3) requirement for 20% EV Ready parking.
- With 100% EV Ready parking. The 100% EV Ready parking scenarios feature various electrical designs. Some scenarios' electrical designs comply with the TGSv3's limits on how much load sharing between EVs could be implemented; other scenarios featured higher levels of load sharing, which AES's analysis indicates can be appropriate for communities where vehicles travel on average of 45km or less per weekday.

The high-rise archetype was evaluated in both Toronto Hydro and Alectra utility territories, reflecting differences in supply voltages and service policies in these territories.

For each electrical design, cost estimates were made. Figures ES-1 through ES-5 summarize the cost estimates for the various archetypes' different electrical design scenarios. Costs are broken down into different categories of costs, including metering; communications systems; EV panels and cabling; feeders; and increases to utility service / transformer rating.

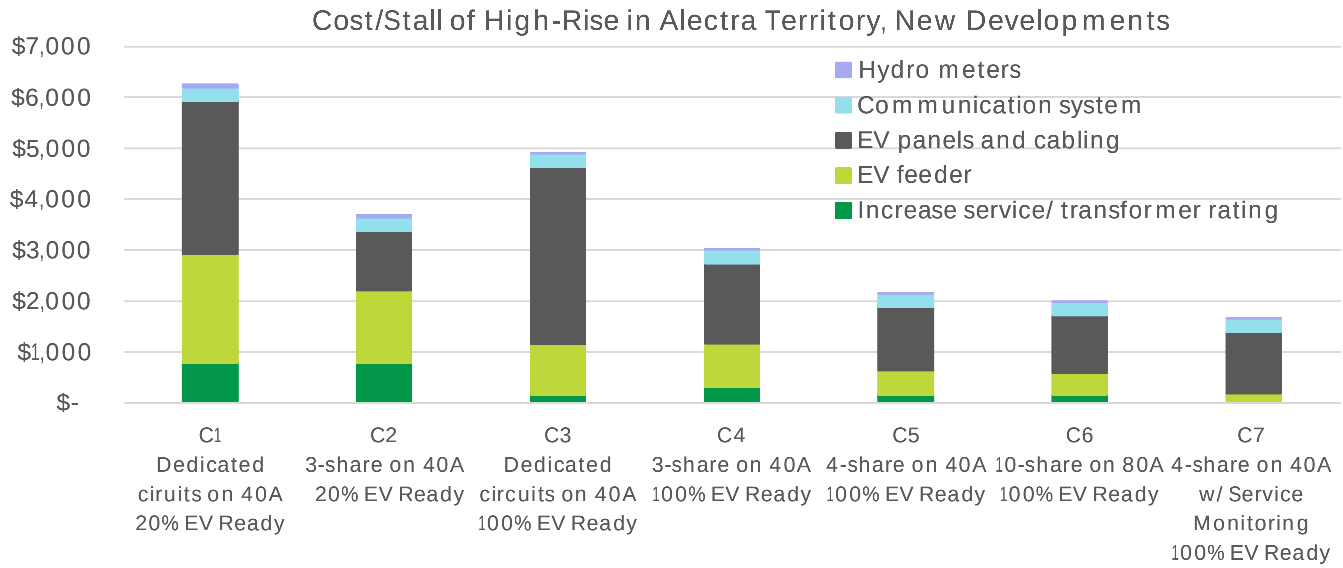


Figure ES-1: Cost of EV charging infrastructure for the high-rise archetype in Alectra's utility territory

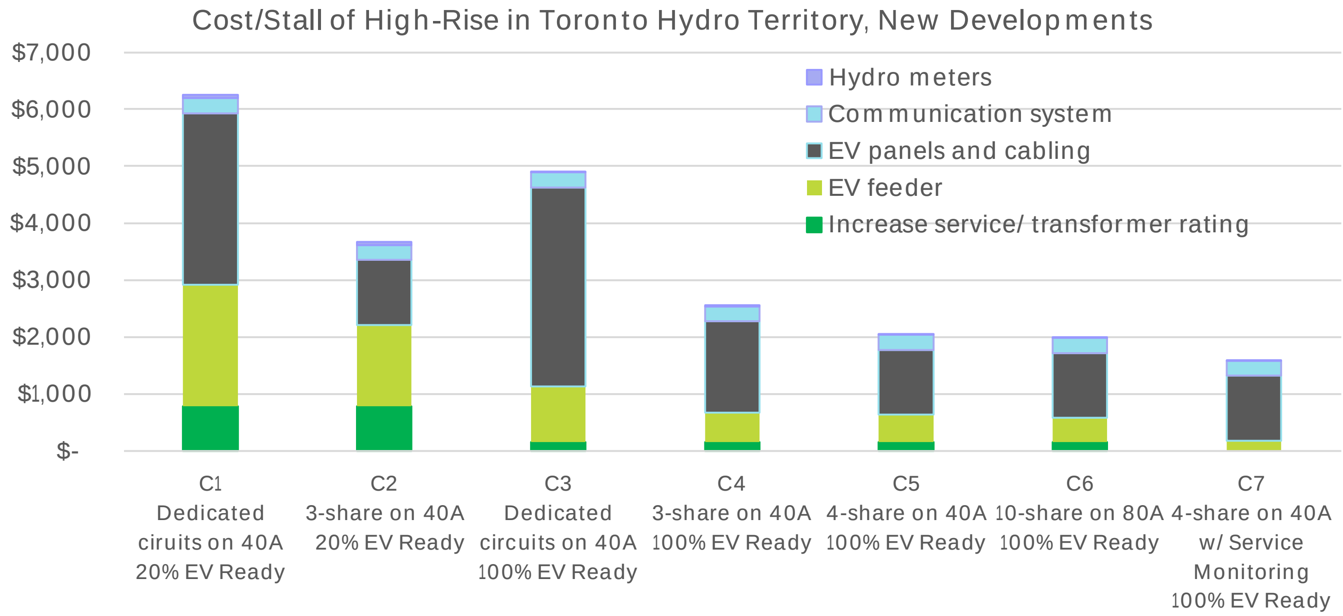


Figure ES-2: Cost of EV charging infrastructure for the high-rise archetype in Toronto Hydro utility territory

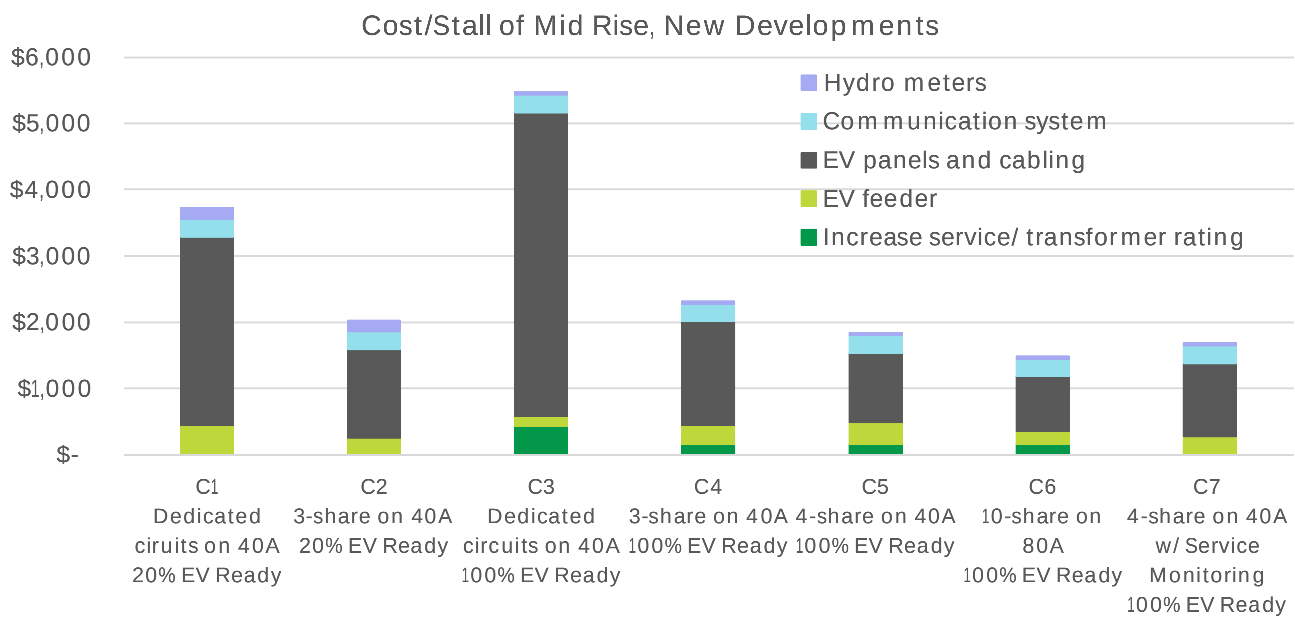


Figure ES-3: Cost of EV charging infrastructure for the mid-rise archetype

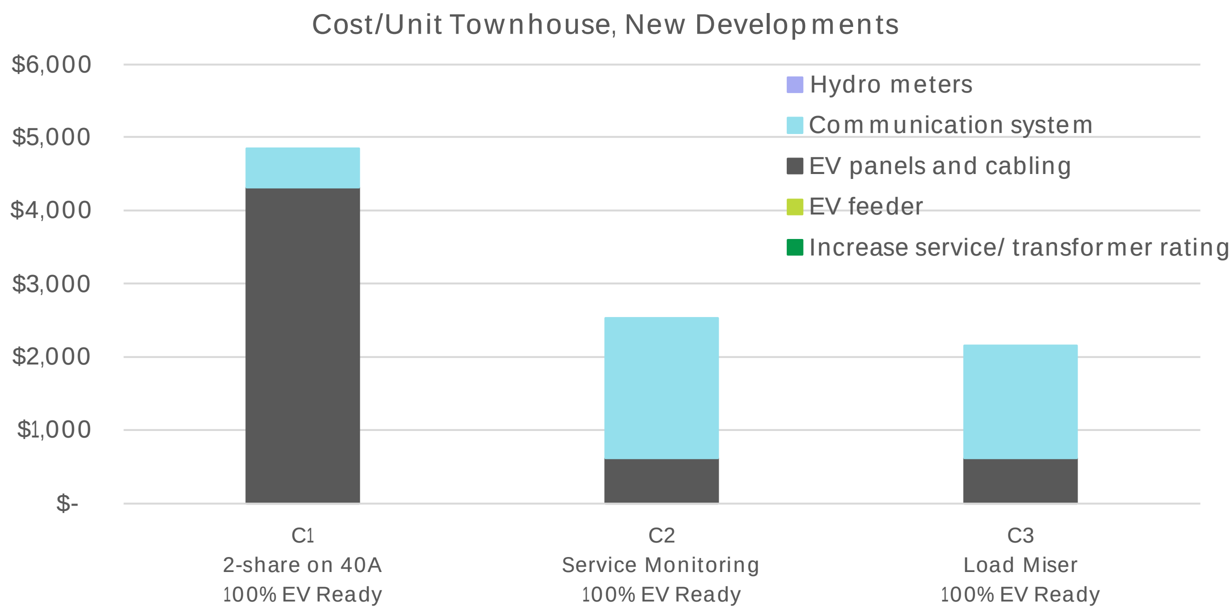


Figure ES-4: Cost of EV charging infrastructure for the townhouse archetype

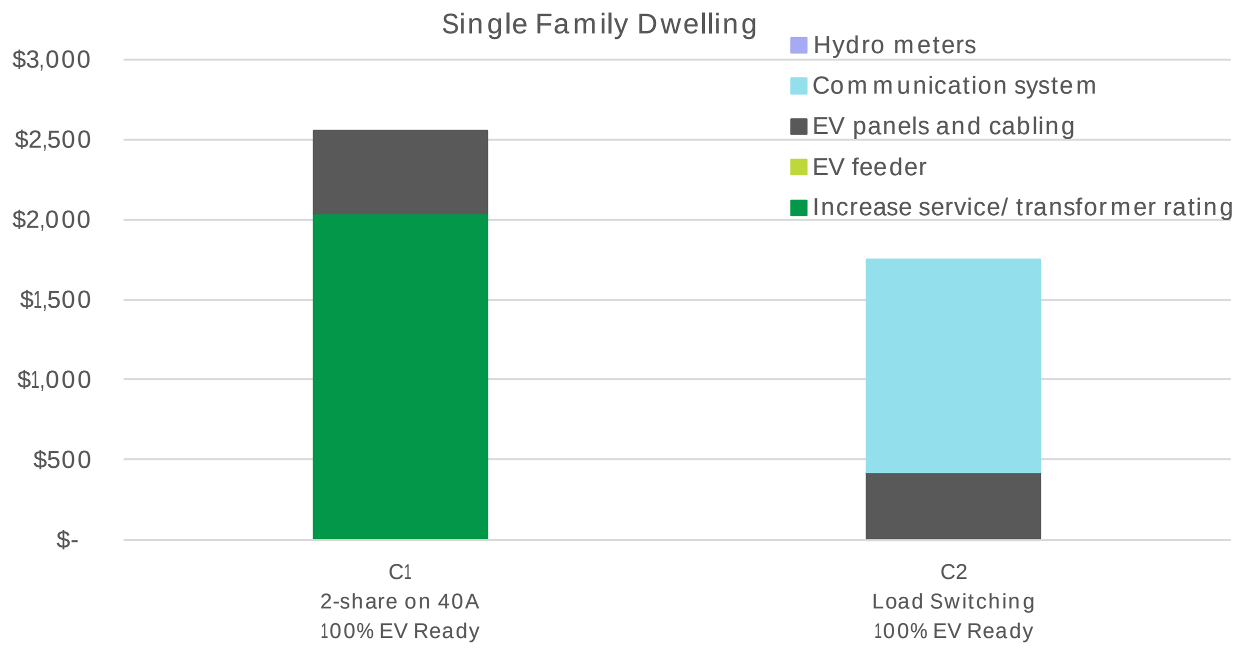


Figure ES-5: Cost of EV charging infrastructure for the single family archetype

This costing analysis suggests that in the high-rise and mid-rise archetypes, it is possible to implement 100% EV Ready parking for approximately $1500 to $1800 per parking space. For the townhouse and single family subdivision archetypes, parking can be made EV Ready at a cost of approximately $2000 or less per dwelling unit with onsite parking. These costs represent a small fraction of the cost for a new development to provide onsite parking. Moreover, future-proofing buildings with this EV charging infrastructure will realize significant value for drivers, enabling them to adopt EVs and benefit from associated savings in total cost of ownership. The costing analysis documents that retrofits to provide EV charging infrastructure in buildings that are not future-proofed with 100% EV Ready parking will be much more costly and complicated than implementing 100% EV Ready parking in new construction.

It is recommended that local governments implement 100% EV Ready requirements for residential parking in new developments.

1. Definitions

This section defines terms related to EV charging infrastructure.

- Electric Vehicle (EV): A vehicle that can plug-in to an external source of electricity (e.g. the electrical grid) to charge an onboard battery that powers the vehicle. EVs include pure battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).
- Electric Vehicle Supply Equipment (EVSE): "A complete assembly consisting of cables, connectors, devices, apparatus, and fittings installed for the purpose of power transfer and information exchange between the branch circuit and the electric vehicle" [1]. Commonly referred to as an EV charging station or EV charger.
- EV Ready Parking Stall: A parking stall that has an adjacent electrical outlet (i.e. a junction box with a cover plate, or a receptacle) at which an EVSE can be installed in the future. Drivers will install EVSE at EV Ready parking stalls over time, as they adopt EVs.
- Level 1 (L1) EVSE: An EVSE which supplies alternating current (AC) power, with nominal supply voltage of 120V single-phase power with maximum current of 12A (1.44kW) [2]. The voltage and amperage of L1 EVSE is typical of a regular household outlet. At 1.44kW, a L1 charger can provide approximately 4km to 8km of range per hour, depending on the vehicle.
- Level 2 (L2) EVSE: An EVSE which supplies AC power, with nominal supply voltage of 208V to 240V single-phase power, with maximum current of 80A (19.2kW) [2]. At 6.7kW (a common power output), a L2 charger can provide approximately 25km to 40km of range per hour, depending on the vehicle.
- EV Energy Management System (EVEMS): A system to "monitor electrical loads and to control [EVSE] loads", often by remote means [1]. This includes systems that allow for load sharing (one circuit shared between multiple EVSE) and service monitoring (monitoring the service and controlling EVSE to avoid overloading the service), as defined below. CSA Group has published a research paper on EVEMS, which summarizes the range of EVEMS technologies, for those wishing to better understand these systems [3].

- Dedicated Circuits: A configuration of EVSE which includes a dedicated branch circuit to each EVSE, without any load sharing, as depicted in Figure 1. EV charging with dedicated circuits can operate without the use of EVEMS.

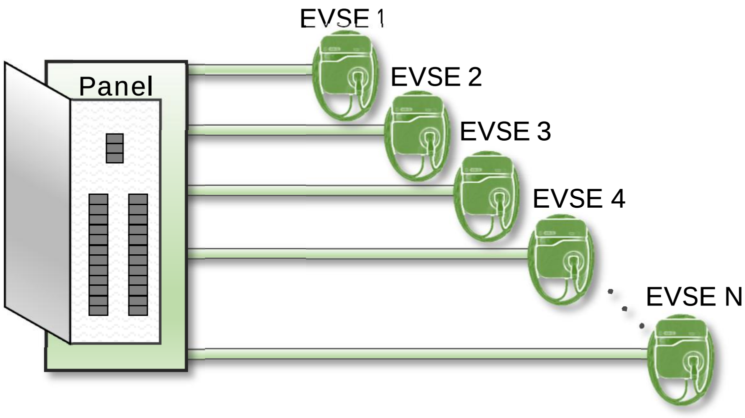


Figure 1: Dedicated circuit configuration of EVSE.

- Load Sharing: Sharing one branch circuit between multiple EVSE, with an EVEMS that controls each EVSE such that the total circuit or panel capacity is not exceeded, as depicted in Figure 2. Load calculations to size the feeder and service use the “maximum load allowed by the [EVEMS]” (CSA C22.1-18 Rule 8-106(10)) [1]. Many EVEMS systems enable load sharing across a branch circuit.

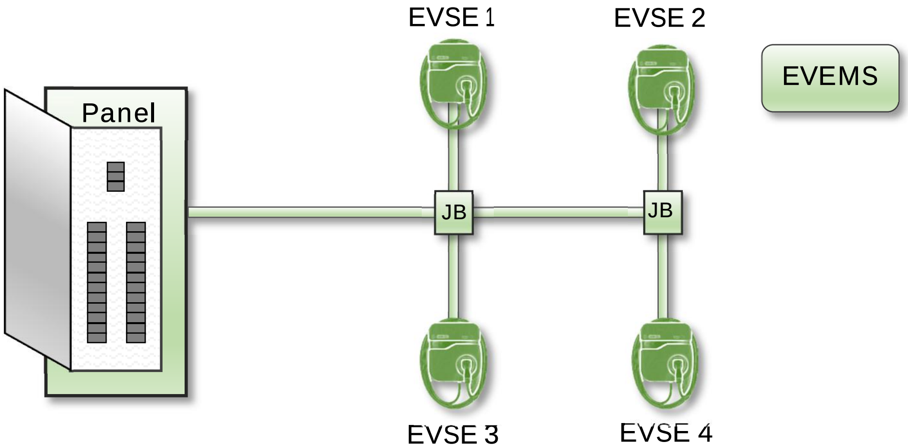


Figure 2: Load sharing configuration of EVSE with EVEMS.

- Service Monitoring: An EVEMS that monitors the load on the service or feeder supplying the EVSE and other loads. This may also be referred to as Building Demand Load Management. The EVEMS controls the EVSE such that the maximum capacity of the service or feeder is not exceeded, as depicted in Figure 3. With a correctly configured service monitoring EVEMS, the load for the EVSE "shall not be required to be considered in the determination of the calculated load" (CSA C22.1-18 Rule 8-106(11)) to size the service or feeder [1]. EVEMS with Service Monitoring capability are currently less common than those that facilitate load sharing across a branch circuit; nevertheless, a variety of EV charging service vendors provide EVSE and EVEMS that can perform service monitoring, and service monitoring technology may be more common in the future.

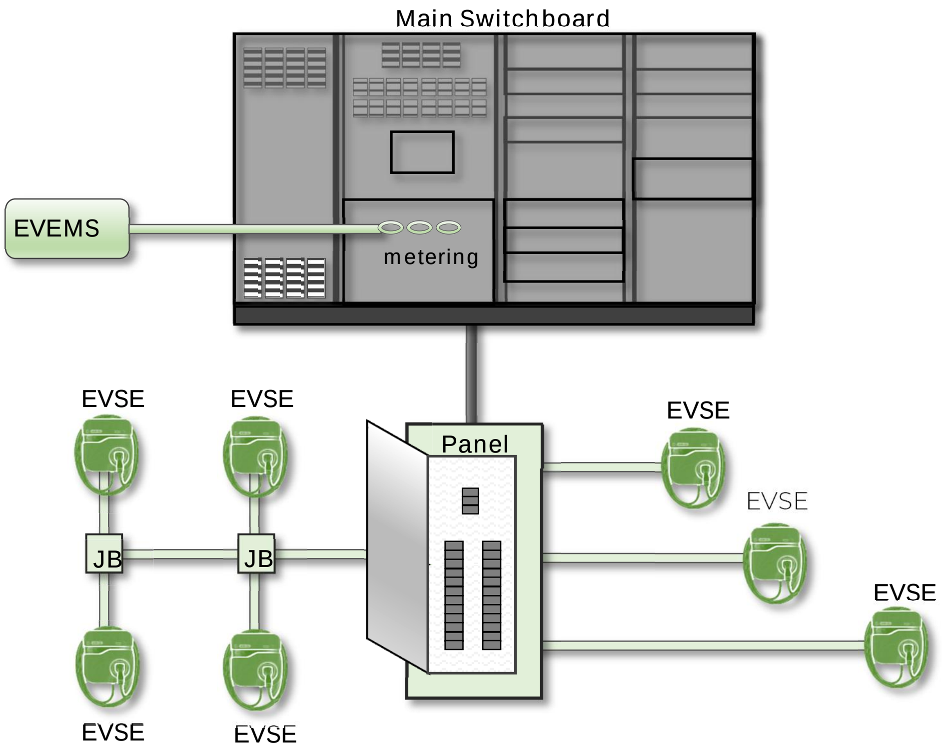


Figure 3: Service monitoring configuration of EVSE with EVEMS.

2. Background

This section provides background information and rationale for EV Ready requirements for new construction.

2.1 EV BENEFITS

EVs realize a variety of benefits for both drivers and broader society, including:

- **Cost savings**. Future EV drivers will save significantly on the life-cycle costs of their vehicles. The fuel cost to charge an EV at home in Ontario are equivalent to roughly $0.20 per litre gasoline [4] (exact costs depend on the timing of EV charging under time-of-use or wholesale pricing utility rates, and other factors relating to utility tariffs and vehicle efficiency). Maintenance costs of EVs are half that of gasoline vehicles [5]. Despite EVs currently typically having higher upfront costs than comparable internal combustion vehicles (ICEVs), on a life cycle cost basis, EVs are already typically competitive with ICEVs [6]. And the purchase and lease costs of EVs are declining, making them more and more advantageous [7].
- **Improved performance.** EVs typically have superior handling. Additionally, EVs are quieter inside, which many drivers report makes for a more enjoyable environment for music and conversation.
- **Reduced GHG emissions, better air quality and improved health**. EVs' lifecycle GHG emissions are about 90% less than fossil fuel vehicles when charging on clean electrical grids like Ontario's, even accounting for raw material production, manufacturing, use and disposal of vehicles [6]. Moreover, EVs have zero tailpipe emissions, improving the health of our communities. The International Council on Clean Transportation and the Climate & Clean Air Coalition estimate that transitioning on-road transportation to EVs in Canada would avoid 900 deaths each year from tailpipe emissions and save $7.8 billion in annual healthcare costs [8].

2.2 EV ADOPTION TRENDS

EV adoption is growing exponentially worldwide and is widely forecast to continue to accelerate rapidly over the coming decade and beyond [9] [10]. The cost to produce batteries used in EVs is declining with technology innovation and increased scale of manufacturing. Because of these cost declines, multiple analysts, including the International Council on Clean Transportation and Bloomberg New Energy Finance, forecast that by the mid-2020s, the cost to produce EVs will be equivalent to internal combustion engine vehicles (ICEVs), and lower cost thereafter [7] [10].

Accordingly, many of the world's largest automakers have announced plans to phase out sales of conventional internal combustion engine vehicles [9] [11]. There is also increasing consumer demand for EVs – A 2021 survey by KPMG suggests that of Canadians planning to purchase an automobile within the next five years, 68% report being likely or very likely to purchase an EV [12].

Public policy is likewise driving EV adoption, with the Government of Canada targeting all sales of passenger vehicles to be zero emissions by 2035 [13]. Achieving local, national, and global climate targets will require the near complete electrification of passenger transportation prior to 2050, 2040 in a best-case scenario.

In summary, despite relatively low levels of adoption of EVs in Ontario in recent years, local governments can confidently expect rapidly growing demand for EVs, and EV charging, in the future. The preponderance of evidence suggests that within 15-20 years, most households will drive an EV, if they have a vehicle.

2.3 THE NEED FOR ACCESS TO HOME CHARGING

The US Department of Energy's "charging pyramid" (see Figure 4) provides a conceptual summary of where passenger vehicle EV charging occurs, including:

- At home. The large majority (currently about 72% in Canada [14] and over 80% in the USA [15]) of passenger EV charging occurs at drivers' home. Access to home charging is a critical factor determining whether households will adopt an EV.
- At work. Approximately 15% of charging occurs at work [14].
- Fleet charging. For vehicles that are part of corporate fleets, almost all charging usually occurs at fleets' "home-base" or depot.

Figure 4: Charging Pyramid. Source: US DOE.

- Public charging. A relatively small proportion of private vehicles' charging occurs at public charging stations. Nevertheless, public charging is important for households without access to home or work charging; to provide "opportunity charging" (i.e. convenient top-up charging when drivers are parked for shopping, recreating, etc.); and to provide for very fast charging on longer trips.

As the upfront costs of EVs continue to decline, access to convenient forms of charging will increasingly become the most important factor determining EV adoption. As home charging is widely recognized as the most convenient form of EV charging, improving access to home charging is particularly important to enabling EV adoption.

2.4 THE CHALLENGE OF RETROFITTING EV CHARGING IN MULTIFAMILY BUILDINGS

For single family homes with their own private onsite parking space (e.g. a garage or parking pad), implementing "at home" EV charging is usually relatively simple and low cost. However, retrofitting EV charging into multifamily buildings is much more complicated and costly. Broadly, multifamily buildings that are not constructed with EV Ready infrastructure can pursue one of two strategies to implement EV charging:

1. Comprehensive EV Ready retrofits. A building undertakes an electrical renovation to make all parking EV Ready. As drivers adopt EVs, EVSE are installed at their assigned parking space.
2. Incremental additions of EV chargers. A building implements a few chargers at a time. Often, EVSE are located in common parking areas (e.g. visitor parking). Over time, as more EVs are adopted by residents, additional EVSE will need to be added.

Table 1 compares these two models for providing EV charging in existing multifamily buildings that have not been future-proofed in new construction for EV charging. Table 1 makes clear that there are significant challenges to retrofitting multifamily buildings to provide EV charging. Comprehensive 100% EV Ready retrofits often provide the greatest value over the life cycle of the building, but are complicated and entail greater costs than future-proofing new construction. To avoid perpetuating the challenge of providing EV charging infrastructure in multifamily buildings, Canadian local governments are increasingly adopting 100% EV Ready residential parking requirements for new construction.

Table 1: Comprehensive EV Ready retrofits vs. incremental EVSE additions

	Comprehensive 100% EV Ready retrofits	Incremental additions of EVSE
Life-Cycle Cost Per Parking Space	Less expensive. Costs will vary significantly from building to building, and depending on design (e.g. extent of load sharing).	Much more expensive on life cycle basis, assuming that all vehicles in multifamily buildings will ultimately be EVs.
Initial Project Cost	Higher one-time initial cost to make all parking EV Ready.	Series of incremental projects. Initial project typically significantly less expensive than comprehensive EV Ready retrofit.
Process	One-time significant electrical renovation.	Repeated electrical renovations.
Location of charging stations	In drivers' assigned parking space.	Often initially in commonly accessible parking (e.g. visitor parking). Sometimes in assigned parking.
Process for drivers to install chargers	Simple process to install chargers (after initial comprehensive electrical renovation).	Process to implement new chargers typically lengthy and complicated.
Convenience	Highly convenient for drivers. Parking & EV charging in regular assigned parking spot.	If chargers are located in commonly accessible parking (e.g. visitor parking), typically less convenient for drivers.
Futureproofing	With EVEMS, frequently can ensure sufficient electrical capacity for all parking spaces to have EV charging.	Initial installations may not be designed for later expansion; potential for stranded assets. Potential to exhaust limited electrical capacity if design for EVEMS not considered.
Market adoption	Currently very uncommon & limited to early adopters with incentive support. The high one-time upfront expense presents a significant barrier for residential condominiums and rental building owners.	Typical approach to adding EV charging in multifamily buildings.

2.5 EV READY REQUIREMENTS

Cities and other jurisdictions are increasingly focused on ensuring that their residents have access to convenient forms of EV charging. Table 2 summarizes EV Ready requirements adopted by a selection of Canadian cities. Other Canadian cities are understood to be considering similar requirements.

Table 2: EV Ready parking requirements in select Canadian jurisdictions (list of jurisdictions is not intended to be comprehensive).

Jurisdiction	EV Ready Parking Requirements	
	Residential	Commercial
City of Vancouver, BC	100%	10%
City of Port Moody, BC	100%	20%
City of Surrey	100%	20%
City of Victoria	100%	~5% (varies by land use)
District of Saanich	100%	~5% (varies by land use)
City of Richmond, BC	100%	
City of Burnaby, BC	100%	
City of New Westminster, BC	100%	
City of North Vancouver, BC	100%	
District of West Vancouver	100%	
District of North Vancouver	100%	
Town of View Royal	100%	
Township of Langley	1 per dwelling unit	
City of Nelson	1 per dwelling unit	10%
City of Coquitlam, BC	1 per dwelling unit	
City of Laval, QC	50% in multifamily buildings	
City of Toronto, ON	25% in multifamily buildings (TGS version 4, Tier 1) 100% in multifamily buildings (TGSv4, Tier 2)	20%
Province of Quebec	All single family dwelling parking	

Local governments with 100% EV Ready requirements have allowed new developments to design for use of EVEMS, reducing the cost of implementing 100% EV Ready parking.

2.5.1 Previous Ontario Building Code Requirements

In May 2017, the Ontario Building Code was amended to include requirements for EV charging systems. The Code required [16]:

- Buildings, except apartments buildings, to be provided with EVSE in 20% of their parking spaces.
- Houses served by a garage, carport or driveway to feature a 200A electrical panel and electrical conduit between the panel and the parking area.

In May 2019, these provisions were revoked. Because there are no Ontario Building Code or other provincial regulatory provisions relating to EV charging infrastructure in buildings, it is understood the Ontario *Building Code Act* does not prevent local governments from adopting requirements for EV Ready parking.

2.5.2 Toronto Green Standard

The Toronto Green Standard (TGS) is the City of Toronto's sustainable design requirements for new private and city-owned developments, and applies to new developments proposed in Toronto. TGS version 3 (TGSv3) required 20% of parking in mid- to high-rise residential buildings and non-residential buildings to be EV Ready. The remainder of parking was required to be served by conduit from the electrical room to the parking space[1]. TGSv3 required that "the system must be capable of supplying a minimum performance level of 16 kWh average per EVSE, over an 8-hour period, assuming that all parking spaces are in use by a charging EV" [17]; this performance requirement allows three EV Ready parking spaces to load share on a 40A circuit.

[1] AES Engineering recommends against requiring residential structural parking to be served by "conduit only" infrastructure. As reviewed later in this report, the large majority of retrofit costs are for other elements electrical infrastructure. Moreover, the configuration of the conduit installed at time of construction may not provide the best orientation for cost-effective electrical retrofits to provide EV charging; there is good likelihood that conduit implemented a new construction would not be optimal and result be a stranded asset. It is important to note that for surface parking, trenching to implement conduit can be particularly expensive, and therefore "conduit only" requirements are better than nothing, though EV Ready parking future-proofing is still recommended as a better option.

In July 2021, TGS version 4 (TGSv4) was released with application to new developments commencing May 1st, 2022. Tier 2 of TGSv4 requires 100% EV Ready residential parking, while Tier 1 of TGSv4 requires 25% of parking in mid- to high-rise residential buildings and non-residential building to be EV Ready and the remainder of parking stalls in multi-use residential buildings (MURBs) to be served by conduit from the electrical room to the parking space. Additionally, TGSv4 updated the performance requirements to include a table (consistent with Table 3 below), effectively allowing greater amounts of load sharing across branch circuits than were allowed in TGSv3. Due to TGSv4 being released at the time of writing, this report offers comparison to TGSv3.

2.6 WHY REQUIRE 100% EV READY PARKING

AES typically recommends jurisdictions adopt 100% EV Ready residential parking requirements. Benefits of EV Ready parking requirements include:

- Consistency with local and national GHG and EV sales targets. As noted above, the Government of Canada has adopted targets for 100% of passenger vehicle sales to be zero emissions by 2035, well within the lifetime of new residential buildings that would be subject to EV Ready requirements.
- Equity between residents, and avoiding challenges associated with trading parking spaces or renovating for EV access. Requirements for 100% "EV Ready" parking stalls provide all residences with equitable access to an outlet that provides adequate electrical capacity for EV charging. If instead, only a portion of parking spaces are made "EV Ready", households without access to such an "EV Ready" space would either need to 1) renovate electrical systems to provide access to EV charging, or 2) trade parking spaces with households that have an EV Ready space.

  Trading parking spaces is typically challenging or not possible in condominiums. Different forms of possible parking tenure in condominiums have different implications for trading parking stalls; however, all present major difficulties for residents of condominiums to trade parking stalls. This is widely recognized by those in the EV charging industry as an impediment to EV adoption, and has been noted by Ontario multifamily developers.

  As noted in section 2.4, retrofitting parking to provide EV charging is costly and complicated. In practice, the challenges associated with trading and/or renovating stalls typically prevent EV uptake in MURBs.

- Avoiding challenges with specifying fixed electrical capacities to support EV charging (e.g. requirements for 200A electrical panels). The Ontario Building Code previously required that "Part 9" residences have 200A electrical panel to support EV charging. In some cases, this requirement triggered electrical service upgrades for developments that would otherwise feature smaller electrical panels and utility services. Instead, requiring EV Ready parking allows for "Part 9" developments to either implement a dedicated circuit, or implement EVEMS that can control loads so as not to exceed the capacity of an electrical panel.
- Relatively simple enforcement. Compared to other ways that jurisdictions have structured requirements for new construction to include EV charging infrastructure, 100% EV Ready requirements are relatively simple for local governments to enforce. Some jurisdictions (e.g. California) have required that new developments provide sufficient electrical capacity on electric panels to provide for future EV charging, but do not require wiring an electrical outlet. However, local building officials, transportation, and/or development approvals staff typically do not possess the requisite experience or qualifications to review electrical plans and calculations. EV Ready requirements necessitates checking for the provision of an electrical outlet, a much simpler task for personnel without electrical background.
- Reasonable cost. As explored below, 100% EV Ready parking can be implemented in new construction at reasonable costs.

3. EV Charging Performance Requirements

To ensure that drivers can receive sufficient charge from EV charging systems, cities' EV Ready requirements typically reference minimum "charging performance requirements". These performance requirements limit the amount of load sharing allowed between EVs. This is intended to ensure that EVs receive an adequate amount of energy to meet drivers' needs.

Appropriate charging performance requirements vary between different geographic areas, based on factors including:

- Daily driving distance. Average vehicle kilometers travelled (VKT) per day varies significantly across and between regions. Generally, vehicles in more suburban or exurban locations will travel farther than in central cities, and thus will require more energy to charge.
- The efficiency of the region's vehicle fleet.
- Temperature extremes, which can reduce vehicles' efficiency.
- Available charging time.
- Charging efficiencies.
- Other factors.

AES has developed a model to determine appropriate charging performance requirements for different geographic regions, which was applied to the GTHA. A companion report "EV Charging Performance Requirements" presents the results of this work in detail. In brief, the model used: VKT data from the Transportation Tomorrow Survey, which collects information about urban travel in southern Ontario; weather data; information about passenger vehicle fleet composition; and reasonable assumptions about resident driving patterns, including arrival and departure times, and the number of vehicles not driving on a given day. The model assumes that almost all EV charging occurs at home, with very limited use of public or workplace charging; of course, vehicles on long trips that extend beyond their range would need additional charging.

The model determines the maximum number of vehicles that may load share across a circuit of a given electrical power capacity, while ensuring that there are no more than:

- 10% of days when vehicles are not fully charged overnight.
- 1% of days when vehicles cannot complete the next day's driving. On those 1% of days, drivers would need to augment home charging with visiting a public charging station, workplace charging, etc.

Table 3 summarizes recommended performance requirements determined by the model, organized by average daily weekday vehicle VKT.

Table 3: Summary of performance requirements in terms of the amount of sharing allowed on each circuit size for different mean VKT.

Circuit Breaker Size	Maximum number of EVs (by mean daily weekday VKT)					
	45km or less	50km	55km	60km	65km	70km
20A	1					
30A	2	2	1	1	1	1
40A	4	3	3	2	2	2
50A	5	4	4	3	3	2
60A	6	5	5	4	4	3
70A	8	7	6	5	5	4
80A	10	8	7	6	6	5
100A	12	10	9	8	7	7
125A	15	14	12	11	10	9

Figure 5 presents VKT data from the TTS.

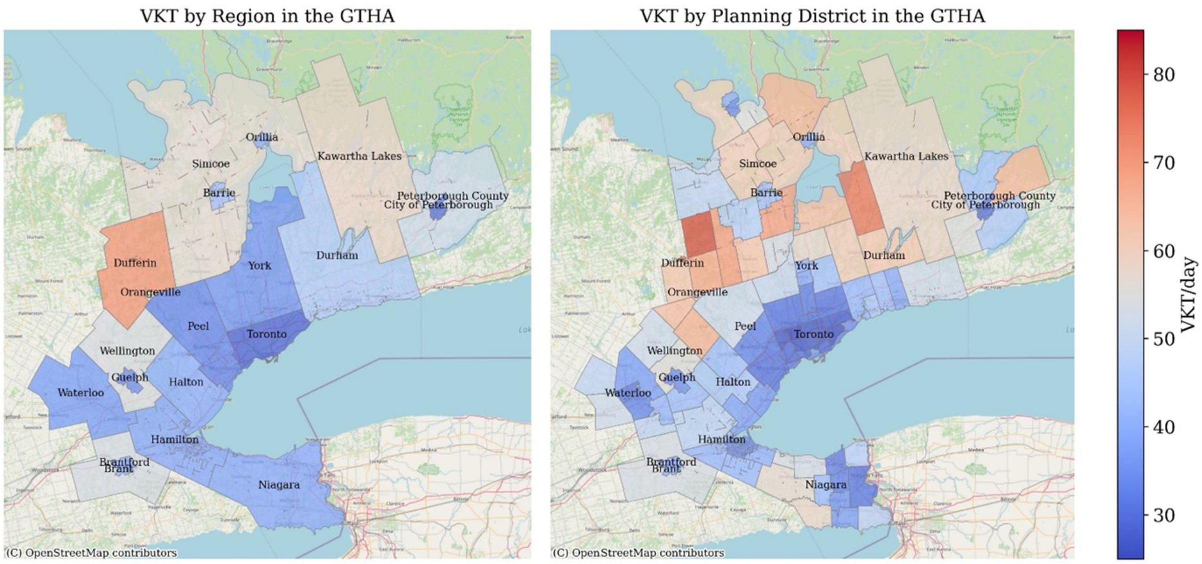


Figure 5: VKT by Region and Planning District in the GTHA. Data from Transportation for Tomorrow Survey.

AES recommends that jurisdictions not adopt performance requirements for new construction that allow for higher levels of load sharing than are presented for jurisdictions with VKT of 45km in Table 3 above. The rationale for such a minimum baseline performance standard for all communities is that:

- Some vehicles may not accept less than 8A.
- It is anticipated prospective EV drivers will have expectations for speed of charging and quality of service that greater degrees of load management will not meet.
- EV charging service providers have indicated hesitancy to service buildings with greater levels of load sharing, which may limit availability of EVEMS systems for buildings designed for higher levels of load management.
- Average VKTs may increase in the future. The introduction of greater use of ride-hailing and car-sharing, and reduction in the number of parking spaces in new developments and associated decline in car ownership, may increase average VKTs.
- The growing tendency for larger vehicles in Canada may decrease future fleet efficiencies.

3.1 IMPLICATIONS FOR GTHA EV CHARGING PERFORMANCE REQUIREMENTS

AES's model suggests that the City of Toronto, and other more central communities in the GTHA with lower daily VKTs, could reasonably specify performance requirements that allow for more sharing than was allowed under the City of Toronto's TGSv3 requirement, which specifies that EV charging systems be able provide "16 kWh average per EVSE, over an 8-hour period, assuming that all parking spaces are in use by a charging EV". For example, the TGSv3's requirement allows only 3-share on a 40A circuit; AES's model suggests 4-share on a 40A circuit is sufficient for communities with daily average VKTs of 45km or less, which includes the City of Toronto.

More suburban communities with longer VKTs could consider adopting more stringent performance requirements in accordance with their communities' average VKT values in Table 3. Alternately, they could adopt less stringent performance requirements (e.g. the performance requirement identified in Table 3 for communities with 45km or less VKT), which would not provide for fully reliance on home charging. Adopting these less stringent performance requirements would effectively require that some drivers augment home charging with workplace charging or public charging, and/or that daily driving distances decline in the future.

4. EV Charging Infrastructure Cost Analysis

This section reviews analysis of the electrical designs and associated costs of providing EV Ready parking in four residential building archetypes common to the GTHA. For each archetype, a range of different electrical design scenarios were developed. These scenarios included those:

- Complying with the current Toronto Green Standard version 3 (TGSv3). These scenarios reflect "business as usual" in the City of Toronto for applicable residential building types.
- Implementing 100% EV Ready parking. The 100% EV Ready parking scenarios included different electrical design. Some scenarios complied with the TGSv3's performance requirements (16kWh for each EV over 8 hours of charging). Other scenarios were designed to the performance requirements determined through AES's modeling to be appropriate for GTHA communities with 45km or less daily VKT, as described in Section 4 of this report above.

The scenarios' electrical designs included different load sharing strategies, as well as service monitoring strategies.

Costs for each scenario were estimated, relative to a baseline development with no EV charging infrastructure. Additionally, the cost of implementing the same electrical systems in a retrofit context were estimated; this analysis is intended to serve as a rough estimate of the cost of retrofitting buildings to feature EV charging infrastructure.

This costing analysis does not include the purchase or installation cost of EVSE or ongoing fees for EVEMS, as these costs are not expected to be required to be borne by building developer. However, a brief discussion of these costs is provided in Section 5.4.

Details of the electrical designs for different scenarios and of the costing analysis are provided in Appendices as follows:

- Appendix A: Archetype details and load calculations.
- Appendix B: Single line diagrams.
- Appendix C: Parking layout drawings.
- Appendix D: Costing estimates.
- Appendix E: Cost categories.

4.1 ABOUT THE ARCHETYPES

Four residential development archetypes were assessed: A high-rise residential development, a mid-rise residential development, a townhouse development, and a single family subdivision. These building archetypes are common in the GTHA, and were derived from actual development applications in the City of Mississauga. A summary of the archetypes is provided in Table 4. EV Ready parking was designed for resident parking only, and not visitor parking stalls.

Table 4. Overview of parking for each archetype.

#	Archetype	Storeys	Number of Units	Parking Stalls	
				Resident	Visitor
1	High-Rise	16	405	369	61
2	Mid-Rise	7	151	104	38
3	Townhouse	3	19	38	5
4	Single Family	3	22	44	7

4.2 EV READY SCENARIOS

The sub-sections below summarize the different electrical design configurations and associated EVEMS control schemes for the development archetypes.

4.2.1 High-Rise

Table 5 summarizes the EV Ready configuration scenarios considered for the high-rise development, including:

- Scenarios complying with TGSv3 requirements for 20% EV Ready parking.
    - C1 features dedicated 40A circuits.
    - C2 features 3-share on 40A circuit load sharing, as allowed by TGSv3.
- 100% EV Ready scenarios.
    - C3 features dedicated 40A circuits to each parking space.
    - C4 features 3-share on 40A circuit load sharing, adhering to the performance requirements in the TGSv3.

- C5 features 4-share on 40A circuits, adhering to the performance requirements recommended in section 4 of this report GTHA communities with daily VKTs of 45km or less.
- C6 features 10-share on 80A circuits, adhering to the performance requirements recommended in section 4 of this report GTHA communities with daily VKTs of 45km or less.
- C7 features 4-share on 40A circuits with service monitoring, adhering to the performance requirements recommended in section 4 of this report GTHA communities with daily VKTs of 45km or less.

Table 5: High-rise scenarios summary.

#	Electrical configuration description	% Residential Parking that is EV Ready	Nominal EVSE Power (kW)	EV Ready Spaces per Branch Circuit	Circuit Breaker Rating (A)	Max Current (A)
C1	Dedicated 40A circuit	20%	6.7	1	40	32
C2	3-share on 40A	20%	6.7	3	40	32
C3	Dedicated 40A circuit	100%	6.7	1	40	32
C4	3-share on 40A	100%	6.7	3	40	32
C5	4-share on 40A	100%	6.7	4	40	32
C6	10-share on 80A	100%	6.7	10	80	64
C7	4-share on 40A with service monitoring	100%	6.7	4	40	32

The high-rise archetype scenarios were evaluated separately for construction in both Toronto Hydro and Alectra utilities' territories. The high-rise archetype was evaluated in both utility territories due to differences in the available primary service voltages and other aspects of utility services.

4.2.2 Mid-Rise

Table 6 summarizes the EV Ready configuration scenarios considered for the mid-rise development:

- Scenarios complying with TGSv3 requirements for 20% EV Ready parking.
  - C1 features dedicated 40A circuits.
  - C2 features 3-share on 40A circuit load sharing, as allowed by TGSv3.

- 100% EV Ready scenarios.
  - C3 features dedicated 40A circuits to each parking space.
  - C4 features 3-share on 40A circuit load sharing, adhering to the performance requirements in the TGSv3.
  - C5 features 4-share on 40A circuits, adhering to the performance requirements recommended in section 4 of this report GTHA communities with daily VKTs of 45km or less.
  - C6 features 10-share on 80A circuits, adhering to the performance requirements recommended in section 4 of this report GTHA communities with daily VKTs of 45km or less.
  - C7 features 4-share on 40A circuits with service monitoring, adhering to the performance requirements recommended in section 4 of this report GTHA communities with daily VKTs of 45km or less.

Table 6: Mid-rise scenarios summary.

#	Electrical configuration description	% Residential Parking that is EV Ready	Nominal EVSE Power (kW)	EV Ready Spaces per Branch Circuit	Circuit Breaker Rating (A)	Max Current (A)
C1	Dedicated 40A circuit	20%	6.7	1	40	32
C2	3-share on 40A	20%	6.7	3	40	32
C3	Dedicated 40A circuit	100%	6.7	1	40	32
C4	3-share on 40A	100%	6.7	3	40	32
C5	4-share on 40A	100%	6.7	4	40	32
C6	10-share on 80A	100%	6.7	10	80	64
C7	4-share on 40A with service monitoring	100%	6.7	4	40	32

4.2.3 Townhouse

Table 7 summarizes the EV Ready configuration scenarios considered for the townhouse development:

- C1 features 2-share on 40A circuits to each garage, serving the two parking spaces associated with each residential unit.

- C2 features 2-share on 40A circuit to each garage, with service monitoring of the townhouse developments electric utility services.
- C3 features 2-share on 40A circuit to each garage, with a load miser that can switch power supply between EV charging and another load (e.g. clothes dryer).

Table 7: Townhouse scenarios summary.

#	Electrical configuration description	% Residential Parking that is EV Ready	Nominal EVSE Power (kW)	EV Ready Spaces per Branch Circuit	Circuit Breaker Rating (A)	Max Current (A)
C1	2-share on 40A (one EV Ready outlet per household)	100%	6.7	2	40	32
C2	2-share on 40A with service monitoring	100%	6.7	2	40	32
C3	2-share on 40A with load miser	100%	6.7	2	40	32

Relative to the high-rise and mid-rise archetypes, there is a limited amount of load sharing that is practical in the townhouse archetypes. All townhouse units have a garage, and EV charging is supplied from the residential unit panel to the garage parking spaces. Load sharing between garages is not practical, nor allowed under Canadian Electrical Code (CEC) rule 26-564(a) [1]. However, load sharing between the two parking spaces in the garage (or in the garage and on the driveway) is very practical and is the expected configuration for this archetype. Therefore, in all scenarios, 2-way load sharing on a 40A circuit is used.

Due to the limited amount of load sharing possible for this archetype, an additional energy management strategy, service monitoring, is also considered in scenario C2. Configuration C2 assumes the same EVSE layout as C1, with the addition of hardware and an EVEMS to monitor the load on the service to each electrical closet and control EVSE loads to avoid overloading the service. According to CEC rule 8-106(11), the EVSE demand load is therefore not required to be considered in the total service load calculation, therefore avoiding any service upgrades.

Similarly, C3 includes a load miser which allows for the EVSE to only be used when there is power available in the circuit, switching off power if the circuit is in use by another load (e.g. a clothes dryer).

4.2.4 Single Family Subdivision

Table 8 summarizes the EV Ready configuration scenarios considered for the single family subdivision development:

- C1 features 2-share on 40A circuits to each garage, serving the two parking spaces associated with each residential unit. Each single family unit features a two car garage.
- C2 features 2-share on 40A circuits to each garage, with load switching.

Table 8: Single family scenarios summary.

#	Electrical configuration description	% Residential Parking that is EV Ready	Nominal EVSE Power (kW)	EVs per Circuit	Circuit Breaker Rating (A)	Max Current (A)
C1	2-share on 40A (one EV Ready outlet per household)	100%	6.7	2	40	32
C2	2-share on 40A with load switching	100%	6.7	2	40	32

4.3 COSTING ANALYSIS FOR NEW DEVELOPMENTS

This section summarizes the results of the costing analysis for the four archetypes.

4.3.1 High-Rise Residential

Figures 6 and 7 summarize the estimated costs per EV Ready parking space for the high-rise archetype constructed in Alectra and Toronto Hydro's utility territory, respectively. Costs are broken down into different categories of costs, including metering; communications systems; EV panels and cabling; feeders; and increases to utility service / transformer rating. The systems included in these categories are further summarized in Appendix E.

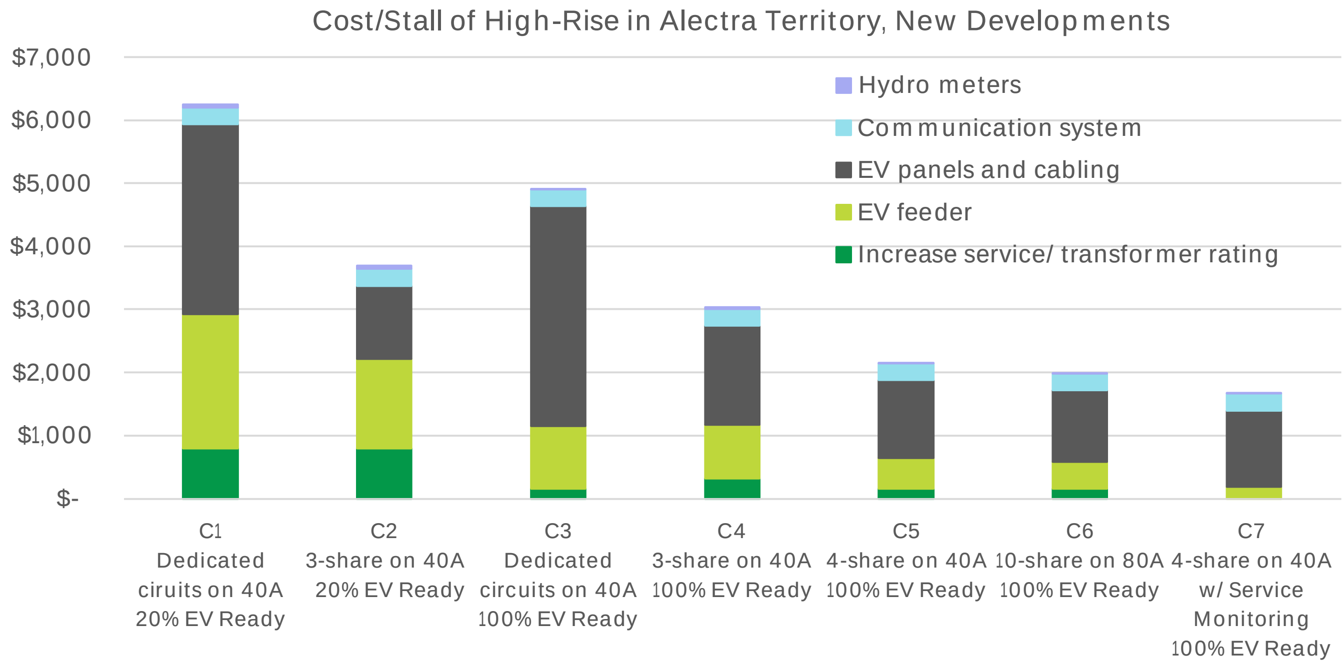


Figure 6 Cost of EV charging infrastructure for the high-rise archetype in Alectra's utility territory

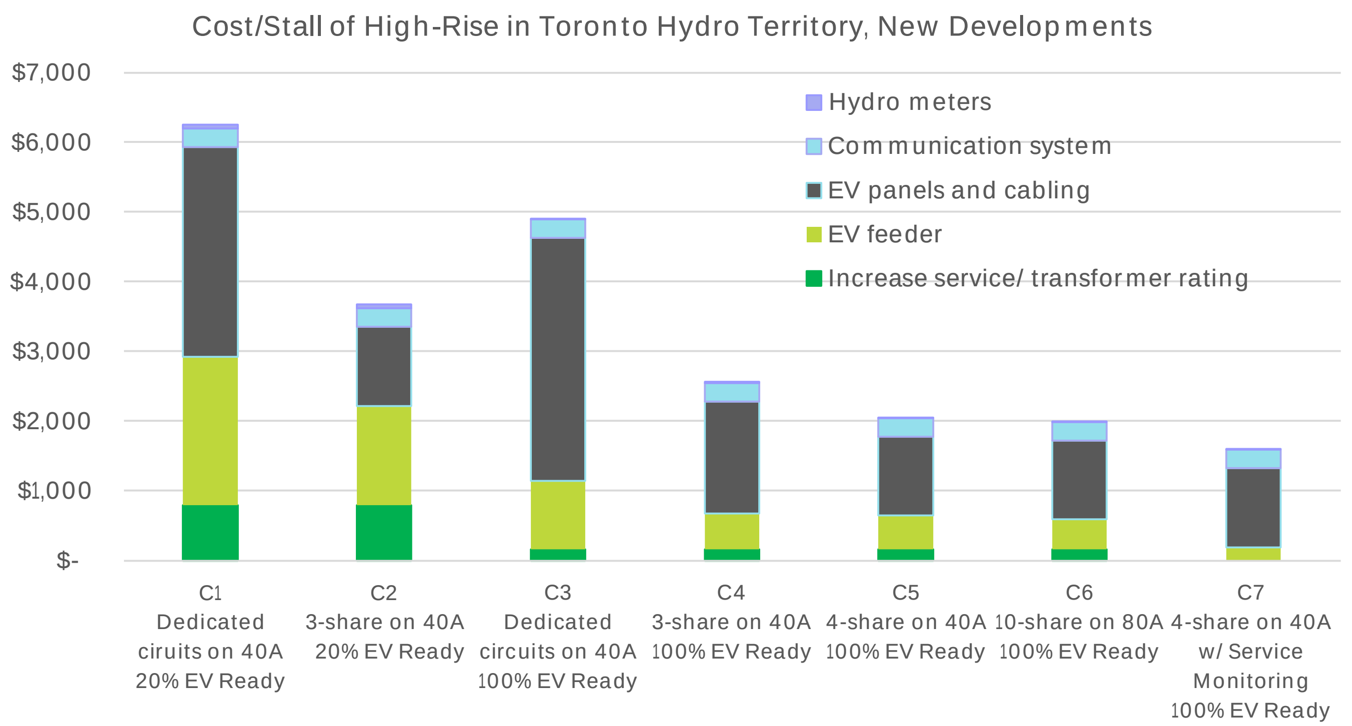


Figure 7 Cost of EV charging infrastructure for the high-rise archetype in Toronto Hydro utility territory

4.3.2 Mid-Rise Residential

Figure 8 summarizes the estimated costs for EV Ready infrastructure.

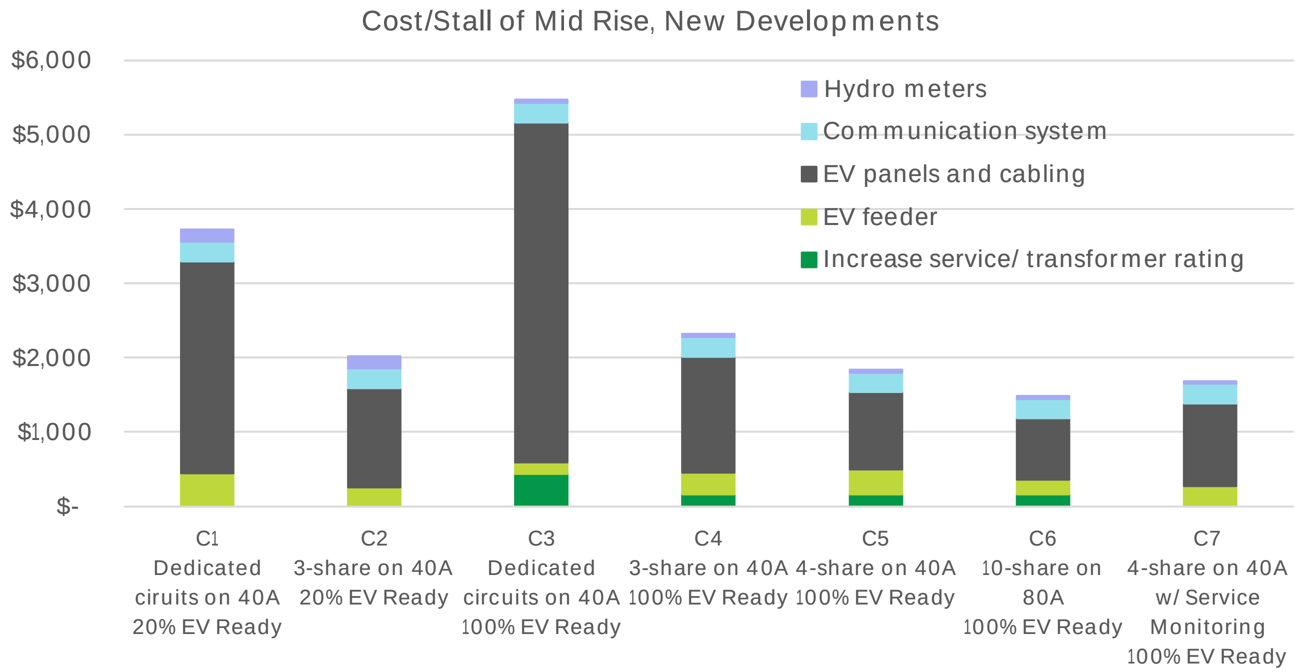


Figure 8 Cost of EV charging infrastructure for the mid-rise archetype

4.3.3 Townhouse

Figure 9 shows the cost per housing unit for EV Ready parking for the townhouse archetype for each configuration for new developments. Note that units here differ from the high-rise and mid-rise archetype results which were reported in cost per energized parking stall. Cost per housing unit is expected to be the relevant value of interest for the development community and other stakeholders when considering EV Ready parking in townhouse developments.

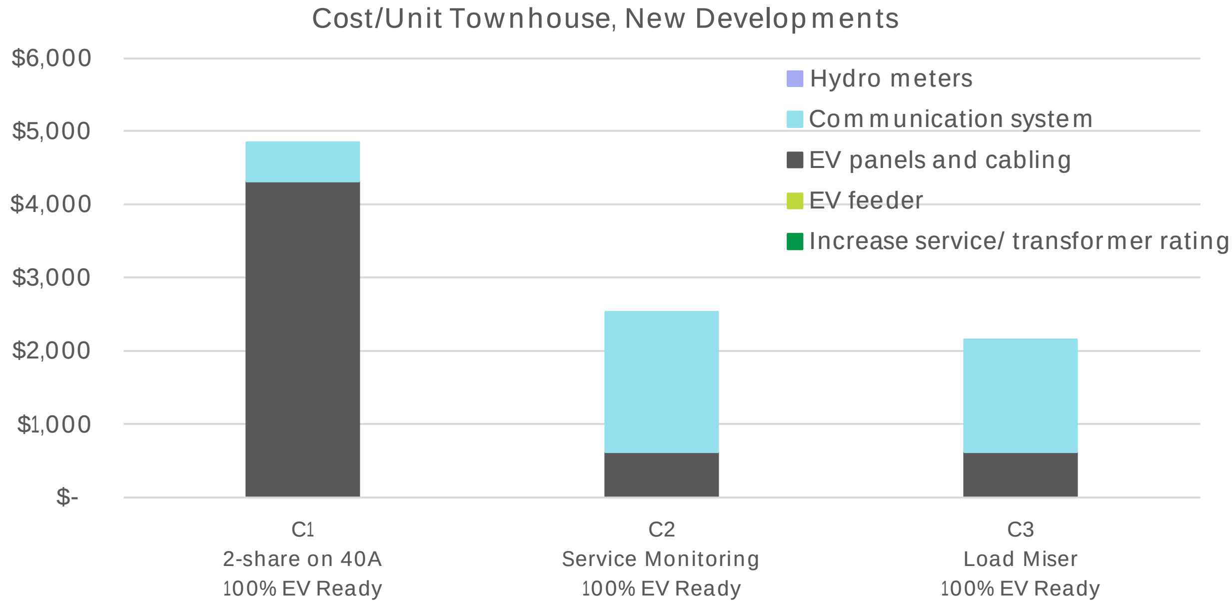


Figure 9 Cost of EV charging infrastructure for the townhouse archetype

4.3.4 Single Family Subdivision

Figure 10 illustrates the cost per housing unit for EV Ready parking in the Single Family Subdivision archetype.

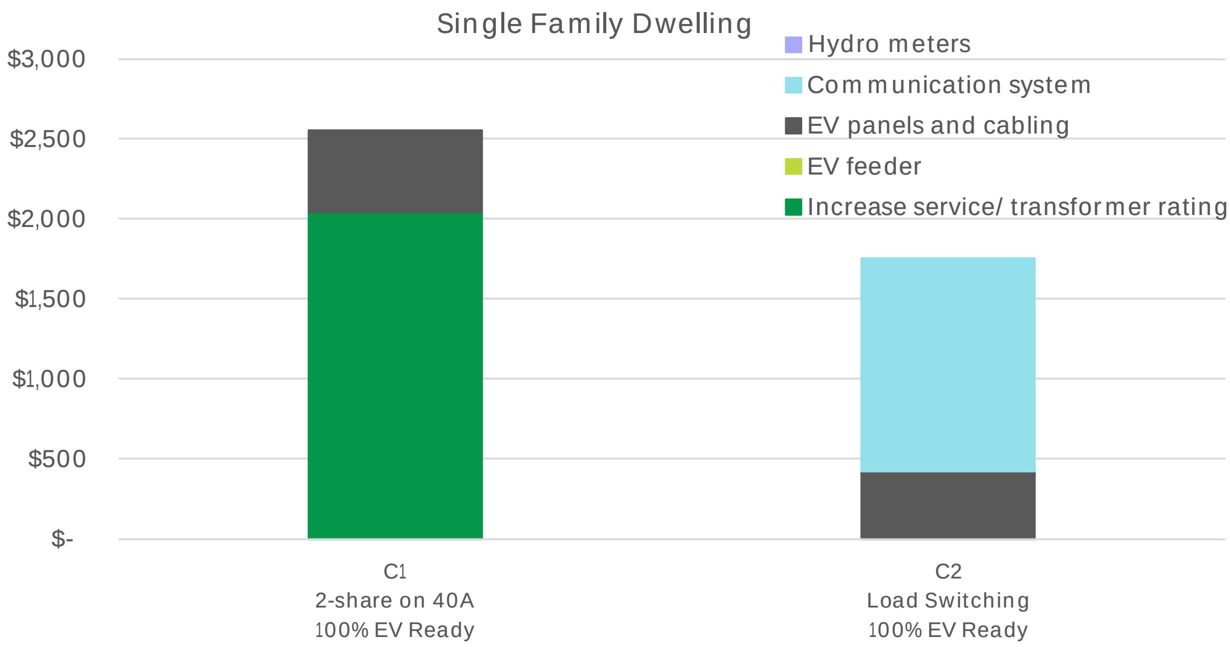


Figure 10 Cost of EV charging infrastructure for the single family archetype

4.4 STRATEGIES TO CONTROL THE COST ASSOCIATED WITH ELECTRICAL SERVICE EXPANSIONS

This study includes cost estimates to increase service sizes and transformer ratings. However, the costs charged to new developments that upgrade service sizes can vary substantially, depending on the nature of electric utility works that will be required to provide electrical service of the necessary capacity to the site.

The Ontario *Distribution System Code* sets the minimum conditions that must be met by Ontario electricity distribution utilities [18]. The *Distribution System Code* specifies that if a utility must construct new facilities to its main electricity distribution system, or increase the capacity of existing distribution system facilities, to connect a customer (e.g. the developer of a new residential building), then the utility will conduct an "economic evaluation" regarding the system expansion costs (i.e. connection costs). The economic evaluation determines whether the customer (e.g. a developer) must make a capital contribution to the system expansion costs. Customers' capital contribution is calculated as the difference between the present value of the expansion's capital and maintenance costs, and the present value of the projected revenue associated with the development (see *Distribution System Code* Section 3.2 & Appendix B) [18].

Distribution utilities' economic evaluations will include a revenue forecast, which will consider the estimated average energy (kWh) and demand (kW) for future customers (*Distribution System Code* 3.2.20 & Appendix B). For expansions that require a capital contribution, distribution utilities require an expansion deposit for up to 100% of the present value of the forecasted revenues (*Distribution System Code* 3.2.20). Once the facilities are energized, distribution utilities annually return the percentage of the expansion deposit in proportion to the actual connections (for residential rate customers) or actual demand (for commercial developments, which typically includes multifamily apartments) that materialized in that year. This process repeats for five years (the "customer connection horizon"), after which distribution utilities are allowed to retain the remaining portion of the expansion deposit (*Distribution System Code* 3.2.23) [18].

Electrical service expansion costs can differ substantially between different development sites, depending on the nature of the capital works that a distribution utility would need to take to provide service to a site. It is possible that EV charging infrastructure can increase the capacity of the electrical service that a development would otherwise feature, and that in some instances this can result in relatively large increases in developments' capital contribution. In these instances, developers and designers are recommended to consider designing for the use of service monitoring, to avoid needing to increase the capacity of developments' service.

Additionally. it is recommended that distribution utilities and developers consider appropriate policies for revenue forecasts, reflecting that the energy and demand load associated with EV Ready parking will emerge over time, and it is unlikely all EV Ready spots will be used by EVs within five years.

4.5 COSTING ANALYSIS FOR EXISTING DEVELOPMENTS

This section provides a rough estimate of the cost to implement EV Ready parking in a retrofit context, if new construction were not made 100% EV Ready. As noted in section 2.4, it is considerably more complicated and costly to implement EV charging infrastructure in a retrofit context, as opposed to making parking EV Ready. This section provides a rough estimate of the cost of incremental additions of EV Ready parking, as described in section 2.4. Figure 11, Figure 12, Figure 13, and Figure 14, outline the costs for high-rise (both Alectra and Toronto Hydro territories), mid-rise, and townhouse, respectively. Costs per parking space for comprehensive 100% EV Ready retrofits will typically be less per parking space than development done incrementally in AES's experience, but still considerably more than future-proofing new construction to be 100% EV Ready. Estimates were made by assigning a cost multiplier for each component of the electrical system. See Appendix D for details of these cost estimates.

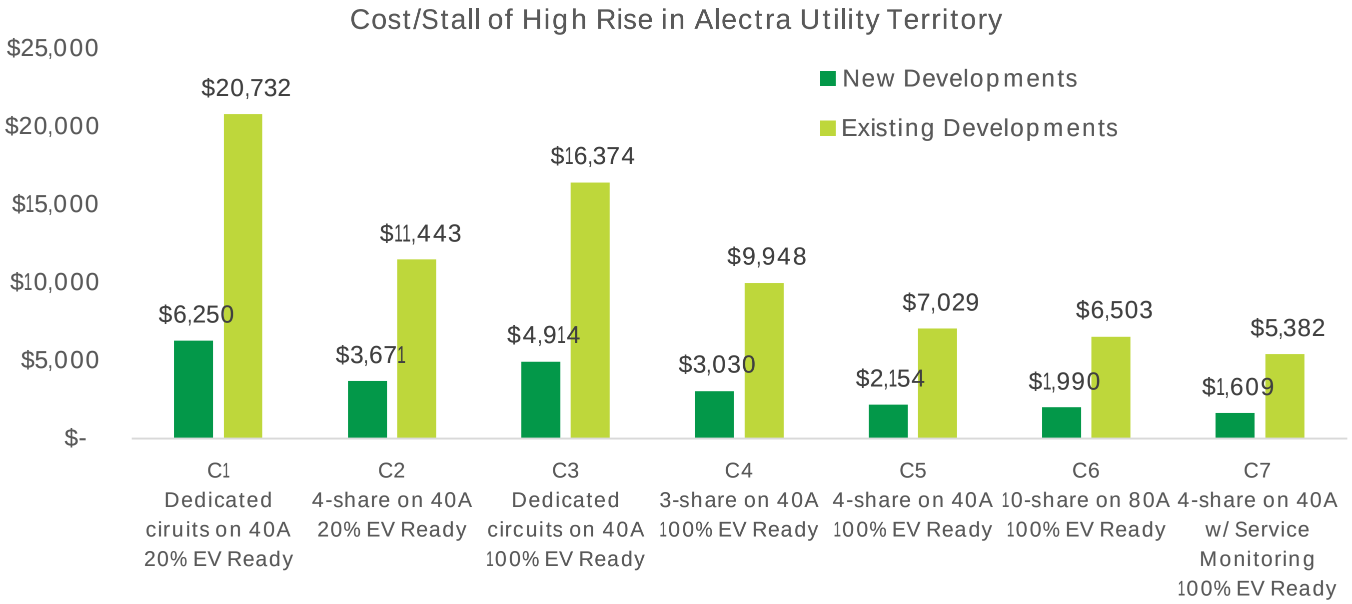


Figure 11 Comparison of cost per energized parking stall of EV charging infrastructure for new and existing developments for the high-rise archetype in Alectra territory

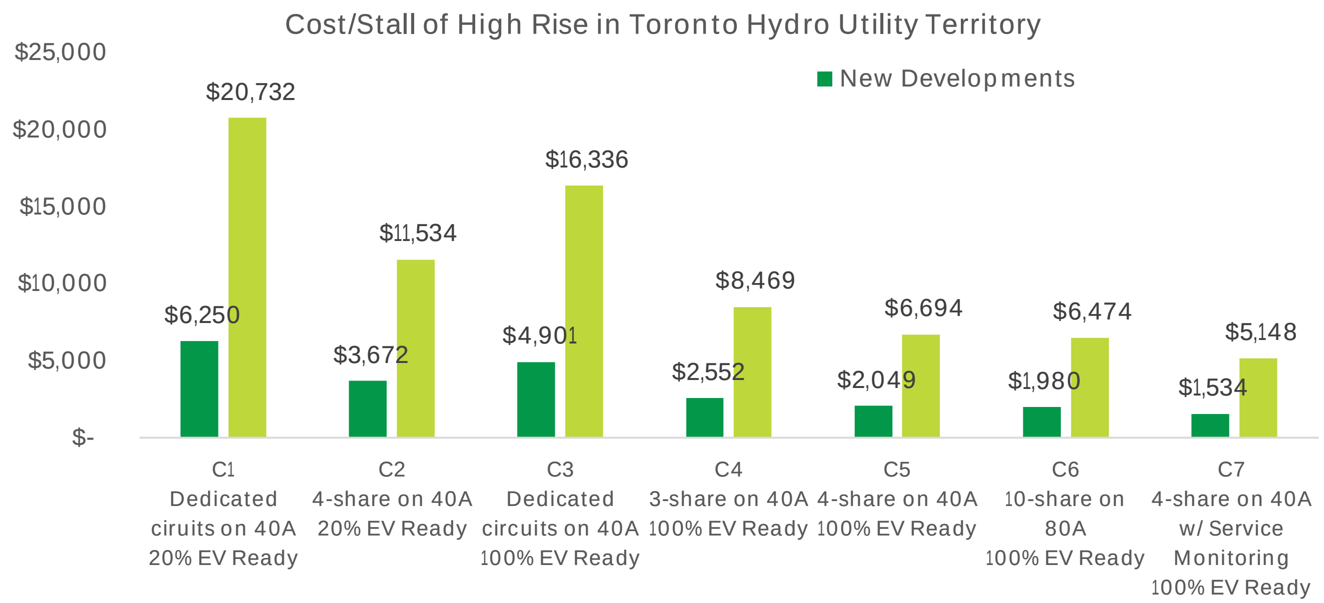


Figure 12 Comparison of cost per energized parking stall of EV charging infrastructure for new and existing developments for the high-rise archetype in Toronto Hydro territory.

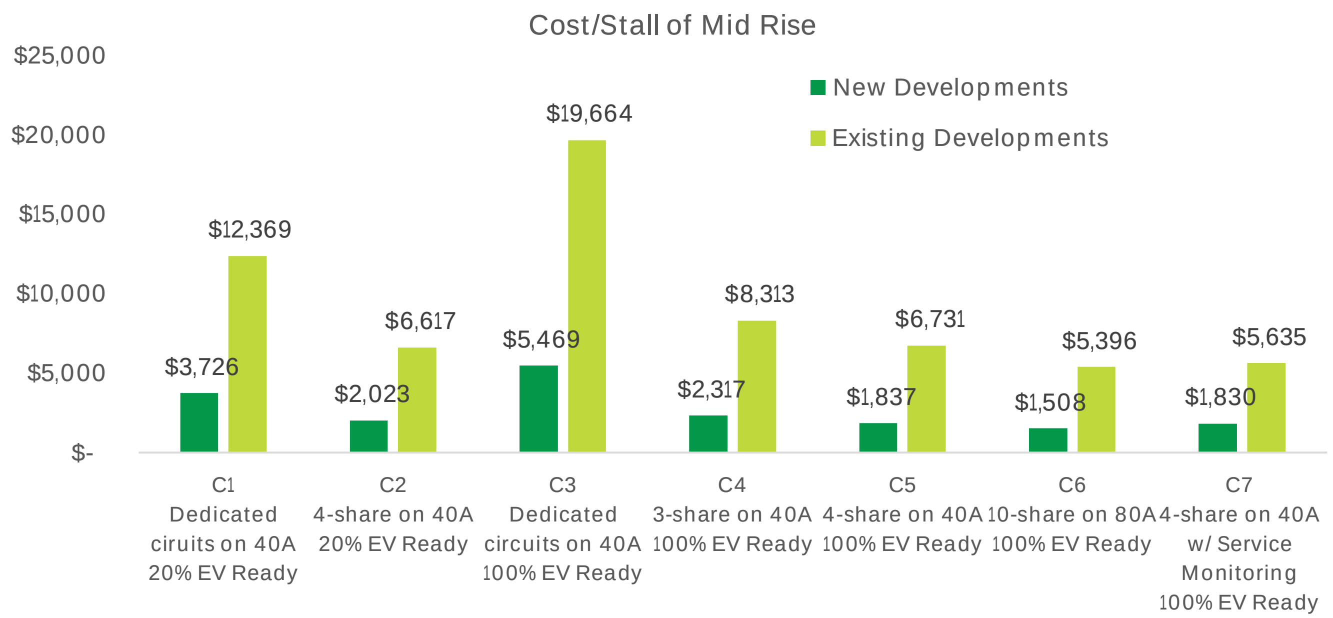


Figure 13 Comparison of cost per energized parking stall of EV charging infrastructure for new and existing developments for the mid-rise archetype

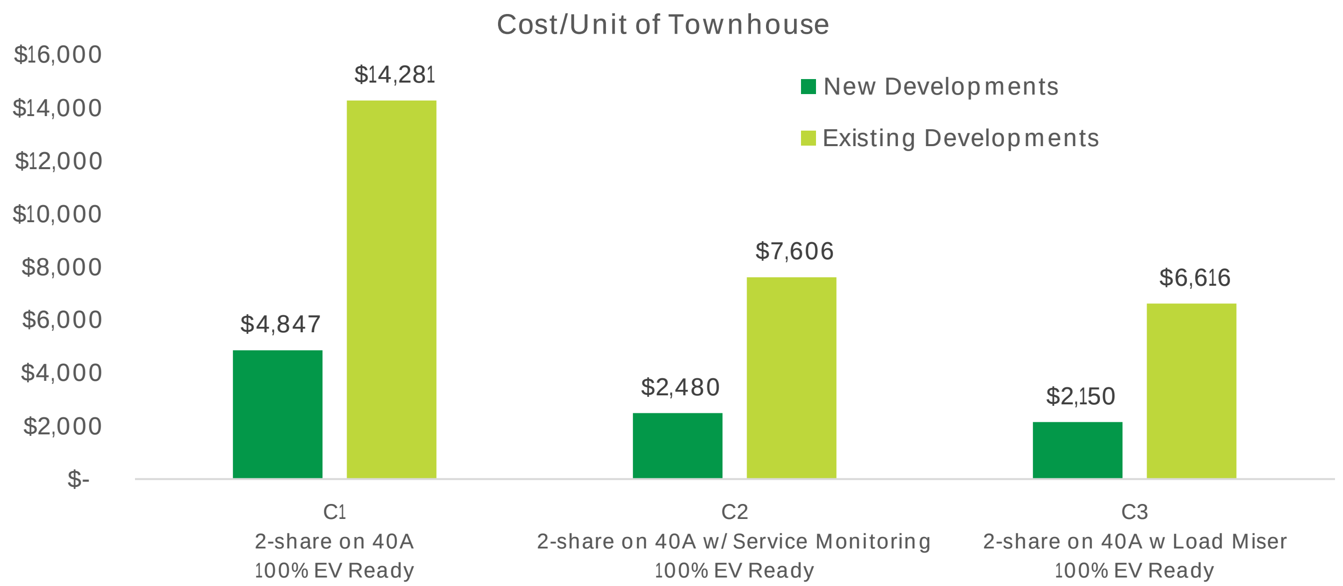


Figure 14 Comparison of cost per unit of EV charging infrastructure for new and existing developments for the townhouse archetype

5. Operating EV Charging Infrastructure

This study focuses on the cost of EV Ready infrastructure for new developments. It does not forecast operating costs for use of this infrastructure. This section provides commentary on the costs to end users of EVSE; EV charging services, including EVEMS; and electricity.

5.1.1 EVSE Costs

The cost of residential level 2 EVSE varies depending on the power level, built-in load sharing, and whether the EVSE can communicate over some network for the purposes of EV energy management and other services (i.e. “smart charging station”). In AES’s experience, installed costs for 7.2kW smart EVSE with appropriate for residential applications range from approximately $1000 to $2000+, depending on the vendor.

Developments with dedicated circuits could use “dumb” EVSE without network connectivity. These dumb EVSE are typically lower cost (e.g. $300 to $1000+). However, use of dumb EVSE may entail higher ongoing utility costs, due to higher demand charges, and broader inability to respond to utility price signals.

5.1.2 EV Charging Services and EVEMS Costs

In EV charging configurations designed for use of EVEMS, EV charging service providers will typically be engaged by multifamily buildings to provide EVSE; EVEMS; and services such as billing drivers for electricity costs, reporting usage data, customer assistance; etc.

Many EVEMS systems currently rely on subscription fees charged on a per station basis. If system communications are achieved via cellular networks, this also includes a network fee. Experience at AES Engineering indicates subscription fees for EVEMS and billing management systems are approximately $240 per station per year, including network fees. RMI estimates network fees to be between $200 USD and $250 USD per station per year, with additional maintenance contracts which could cost $575 USD per charger per year, but which vary widely depending on site specific parameters [19]. Subscription fees can significantly increase operating costs of charging stations. Systems and business models that entail reduced or no subscription fees may increase in the future.

5.1.3 Electricity Costs

As noted in section 2.1, the electricity costs for passenger EVs will be well below fossil fuel costs under a wide range of assumptions. The costs for electricity will depend on the rate charged (e.g. residential rates; commercial rates; special EV charging rates that may emerge in the future). It is possible for EVEMS to facilitate charging in off-peak times under time of use rate constructs. Ultimately, as EV adoption increases, it is likely that time of use rates would be reformed, to encourage EVs to charge throughout the day and not just in what are currently off-peak times; otherwise, EVs would likely ultimately create new system demand peaks and local grid congestion at the start of off-peak times. Design for significant levels of load-sharing assumes that vehicles will be able to charge over large periods of the day, including outside of times that are currently off-peak or have the lowest wholesale power prices.

6. Conclusion

Local governments are increasingly requiring 100% of residential parking in new developments to be EV Ready. This report provides relevant context and background information, and summarizes design and costing analysis for four residential building archetypes common to the GTHA.

This costing analysis suggests that in the high-rise and mid-rise archetypes, it is possible to implement 100% EV Ready parking for approximately $1500 to $1800 per parking space. For the townhouse and single family subdivision archetypes, parking can be made EV Ready at a cost of approximately $2000 or less per dwelling unit with onsite parking. These costs represent a small fraction of the cost for a new development to provide onsite parking. Moreover, future-proofing buildings with this EV charging infrastructure will realize significant value for drivers, enabling them to adopt EVs and benefit from their associated savings in total cost of vehicle ownership. The costing analysis documents that retrofits to provide EV charging infrastructure in buildings that are not future-proofed with 100% EV Ready parking will be much more costly and complicated than implementing 100% EV Ready parking in new construction.

It is recommended that local governments implement 100% EV Ready requirements for residential parking in new developments.

7. References

[1] Canadian Standards Association, "Canadian Electrical Code, Part 1," Canadian Standards Association, Toronto, 2018.

[2] SAE International, "SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler," SAE International, 2017.

[3] K. C. M. S.-z. Clay Howey, "Electric Vehicle Energy Management Systems," CSA Group, 2019.

[4] Ontario Cars, "How Much Does It Cost To Charge An Electric Vehicle," 15 May 2020. [Online]. Available: https://www.blog.ontariocars.ca/how-much-does-it-cost-to-charge-an-electric-vehicle/.

[5] Consumer Reports, "Electric Vehicle Ownership Costs," 2020.

[6] MIT Trancik Lab, "carboncounter," [Online]. Available: carboncounter.com.

[7] International Council on Clean Transportation, "Upate on Electric Vehicle Costs in the United States through 2030," 2019.

[8] International Council on Clean Transportation and Climate & Clean Air Coalition, "A Global Snapshot of the Air Pollution-Related Health Impacts of Transportation Sector Emissions in 2010 and 2015," 2019.

[9] International Energy Agency, "Global EV Outlook," 2021.

[10] I. Boudway, "Batteries For Electric Cars Speed Toward a Tipping Point," Bloomberg, 16 December 2020. [Online]. Available: https://www.bloomberg.com/news/articles/2020-12-16/electric-cars-are-about-to-be-as-cheap-as-gas-powered-models. [Accessed 7 January 2021].

[11] A. White, "Here Are All the Promises Automakers Have Made about Electric Cars," Car and Driver, 21 February 2021. [Online]. Available: https://www.caranddriver.com/news/g35562831/ev-plans-automakers-timeline/.

[12] KPMG LLP, "The next new vehicle purchase for nearly 70 per cent of Canadians will be an electric model: KPMG in Canada survey," Cision, 21 February 2021. [Online]. Available:

https://www.newswire.ca/news-releases/the-next-new-vehicle-purchase-for-nearly-70-per-cent-of-canadians-will-be-an-electric-model-kpmg-in-canada-survey-889637501.html.

[13] Transport Canada, "Zero-emission vehicles," Government of Canada, 31 January 2020. [Online]. Available: https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles. [Accessed 7 January 2021].

[14] Fleetcarma, "Charge the North: Results from the world's largest EV charging study," 2020.

[15] US Department of Energy, "Charging at Home," [Online]. Available: https://www.energy.gov/eere/electricvehicles/charging-home.

[16] "O. Reg. 139/17: BUILDING CODE," Province of Ontario, 17 May 2017. [Online]. Available: https://www.ontario.ca/laws/regulation/r17139.

[17] City of Toronto, "Toronto Green Standard - Air Quality for Mid to High-Rise Residential & all Non-Residential Development," 2019. [Online]. Available: https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-3/mid-to-high-rise-residential-all-non-residential-version-3/air-quality-for-mid-to-high-rise-residential-all-non-re. [Accessed 1 June 2021].

[18] Ontario Energy Board, "Distribution System Code," 2020.

[19] C. Nelder and E. Rogers, "Reducing EV Charging Infrastructure Costs," 2019. [Online]. Available: https://rmi.org/wp-content/uploads/2020/01/RMI-EV-Charging-Infrastructure-Costs.pdf. [Accessed 7 July 2020].

[20] Battery University, "BU-1003: Electric Vehicle (EV)," Battery University, 27 November 2019. [Online]. Available: https://batteryuniversity.com/learn/article/electric_vehicle_ev. [Accessed 6 July 2020].

[21] BC Hydro, "General Service Business Rates," BC Hydro, 2020. [Online]. Available: https://app.bchydro.com/accounts-billing/rates-energy-use/electricity-rates/business-rates.html. [Accessed 7 July 2020].

[22] DCC, "Electric Vehicle Energy Management System," DCC, 2020. [Online]. Available: https://dccelectric.com/. [Accessed 25 August 2020].

[23] VariableGrid, "VariableGrid," VariableGrid, 2020. [Online]. Available: https://www.variablegrid.net. [Accessed 19 August 2020].

[24] AES Engineering, "Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation and Charging Infrastructure Requirements," [Online]. Available: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/electric-vehicles/ev-charging-infrastructure-in-shared-parking-areas.pdf. [Accessed 25 August 2020].

[25] AddEnergie, "CoRe+ Installation Guide for Cascading on a 150A Circuit," 2015. [Online]. Available: https://addenergie.com//download/7741/. [Accessed 3 September 2020].

[26] City of Abbotsford, "Official Community Plan," 2016. [Online]. Available: https://abbotsford.civicweb.net/document/48575/2600-2016%20OCP.pdf. [Accessed 10 December 2020].

[27] AES Engineering Ltd., "Electric Vehicle Charging Infrastructure in New Multifamily Developments- Requirement Options and Costing Analysis," 4 April 2017. [Online]. Available: https://udi.bc.ca/wp-content/uploads/2017/06/Final-Report-r004-EV-Requirements-20170404.pdf. [Accessed 7 January 2021].

[28] Dunsky Energy Consulting, "City of Toronto Electric Vehicle Strategy," 9 December 2019. [Online]. Available: https://www.toronto.ca/wp-content/uploads/2020/02/8c46-City-of-Toronto-Electric-Vehicle-Strategy.pdf. [Accessed 7 January 2021].

[29] City of Toronto, "Toronto Green Standard v3 For Residential Apartment Buildings Greater Than 4 Storeys and All Industrial, Commercial and Institutional Buildings," [Online]. Available: https://www.toronto.ca/wp-content/uploads/2018/03/8f44-City-Planning-TGS-V3-4-storey-res-and-all-non-res.pdf. [Accessed 7 January 2021].

[30] City of Toronto, "Air Quality for Mid to High-Rise Residential & all Non-Residential Development," 2021. [Online]. Available: https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-3/mid-to-high-rise-residential-all-non-residential-version-3/air-quality-for-mid-to-high-rise-residential-all-non-re. [Accessed 7 January 2021].

Appendix A: Archetype details and load calculations

LOAD CALCULATION SUMMARY

<table>
<tr><th></th><th>BASELINE (KW)</th><th>CONFIGURATION</th><th>EV CHARGING (KW)</th><th>TOTAL (KW)</th></tr>
<tr><td rowspan="6">ARCHETYPE 1: HIGH-RISE MIXED USE</td><td rowspan="6">3,046</td><td>C1 - Dedicated circuits on 40A, TGS</td><td>349</td><td>3,395</td></tr>
<tr><td>C2 - 3-share on 40A, TGS</td><td>166</td><td>3,212</td></tr>
<tr><td>C3 - Dedicated circuits on 40A, 100% EV Ready</td><td>2,463</td><td>5,508</td></tr>
<tr><td>C5 - 4-share on 40A, 100% EV Ready</td><td>617</td><td>3,663</td></tr>
<tr><td>C6 - 10-share on 80A, 100% EV Ready</td><td>493</td><td>3,538</td></tr>
<tr><td>C7 - 4-share on 40A, 100% EV Ready with service monitoring</td><td>0*</td><td>3,046</td></tr>
<tr><td rowspan="7">ARCHETYPE 2: MID-RISE MULTIFAMILY</td><td rowspan="7">1,371</td><td>C1 - Dedicated circuits on 40A, TGS</td><td>116</td><td>1,487</td></tr>
<tr><td>C2 - 3-share on 40A, TGS</td><td>60</td><td>1,430</td></tr>
<tr><td>C3 - Dedicated circuits on 40A, 100% EV Ready</td><td>799</td><td>2,169</td></tr>
<tr><td>C4 - 3-share on 40A, 100% EV Ready</td><td>200</td><td>1,570</td></tr>
<tr><td>C5 - 4-share on 40A, 100% EV Ready</td><td>200</td><td>1,570</td></tr>
<tr><td>C6 - 10-share on 80A, 100% EV Ready</td><td>0*</td><td>1,371</td></tr>
<tr><td>C7 - 4-share on 40A, 100% EV Ready with service monitoring</td><td>0*</td><td>1,371</td></tr>
<tr><td rowspan="3">ARCHETYPE 3: TOWNHOUSE</td><td rowspan="3">164</td><td>C1 - 2-share on 40A. 100% EV Ready</td><td>126</td><td>290</td></tr>
<tr><td>C2 - Service Monitoring, 100% EV Ready</td><td>0*</td><td>164</td></tr>
<tr><td>C3 - Load Miser, 100% EV Ready</td><td>0*</td><td>164</td></tr>
<tr><td rowspan="2">ARCHETYPE 4: SINGLE FAMILY HOME</td><td rowspan="2">177</td><td>C1 - 2-share on 40A. 100% EV Ready</td><td>107</td><td>284</td></tr>
<tr><td>C2 - Load Switching, 100% EV Ready</td><td>0*</td><td>177</td></tr>
</table>

*EVEMS will regulate supply to EVSEs based on building usage to stay within the capacity of electrical equipment

ARCHETYPE 1: HIGH-RISE MIXED USE

GENERAL	
Space heating	heat pump system
Range	electric
Air-conditioning	all suites

EQUIPMENT SPECIFICATION			
TYPE	LOAD (HP)	QTY	EFFICIENCY
High Rise Elevators	75	3	75%
Fire Pump	100	1	75%

AREAS		
TYPE	ft^2	m^2
Suites	252,236	23,433
Parking	122,926	11,420
Retail	5,490	510
Base building	62,035	5,763
TOTAL	442,687	41,127

SUITES				
TYPE	No.	AREA		
		ft^2	m^2	TOTAL (m^2)
1 Bed	75	502	47	3,498
1 Bed + Den	284	644	60	16,992
2 Bed	30	667	62	1,859
2 Bed + Den	16	730	68	1,085
TOTAL	405			23,433

SUITE LOADS (KW)							
TYPE	FIRST 45 m^2	NEXT 45 m^2	NEXT 90 m^2	NEXT 90 m^2	RANGE	DRYER @ 25%	LOAD (KW)
1 Bed	3.5	1.5	0.0	0	6	1.25	12.3
1 Bed + Den	3.5	1.5	0.0	0	6	1.25	12.3
2 Bed	3.5	1.5	0.0	0	6	1.25	12.3
2 Bed + Den	3.5	1.5	0.0	0	6	1.25	12.3

RESIDENTIAL	
ITEM	LOAD (KW)
first suite @ 100%	12.3
2^{nd} & 3^{rd} @ 65%	15.9
4^{th} & 5^{th} @ 40%	9.8
6^{th} - 20^{th} @25%	45.9
remainder @10%	471.6
Mechanical (@55W/m^2)	1,288.8
TOTAL	1,844

EQUIPMENT		
ITEM	DEMAND FACTOR	LOAD (KW)
High Rise Elevators	50%	111.9
Fire Pump	100%	99.4
TOTAL		211.3

BASE BUILDING		
ITEM	W/m^2	LOAD (KW)
Basic allowance	30	172.9
Mechanical	55	317.0
TOTAL		489.9

RETAIL		
ITEM	W/m^2	LOAD (KW)
Basic allowance	30	15.3
Mechanical	55	28.1
TOTAL		43.4

PARKING		
ITEM	W/m^2	LOAD (KW)
Basic allowance	10	114.2
Mechanical	30	342.6
TOTAL		456.8

PARKING STALLS	
TYPE	TOTAL
Resident	369
Visitor	61
TOTAL	430

EV CHARGING AND TOTAL LOAD				
OPTION	TOTAL EV-READY CCT	DEMAND	TOTAL EV CHARGING POWER (KW)	TOTAL BUILDING LOAD (KW)
BUILDING ONLY				
Building Only			—	3,046
RESIDENTIAL EV CHARGING OPTIONS				
C1. Dedicated circuits on 40A, TGS	74	70%	349	3,395
C2. 3-share on 40A, TGS	25	100%	166	3,212
C3. Dedicated circuits on 40A, 100% EV Ready	369	100%	2,463	5,508
C5. 4-share on 40A, 100% EV Ready	93	100%	617	3,663
C6. 10-share on 80A, 100% EV Ready	37	100%	493	3,538
C7. 4-share on 40A, 100% EV Ready with service monitoring	93	0%	0	3,046

ARCHETYPE 2: MID-RISE MULTIFAMILY

GENERAL	
Space heating	heat pump system
Range	electric
Air-conditioning	all suites

EQUIPMENT SPECIFICATION			
TYPE	LOAD (HP)	QTY	EFFICIENCY
Mid Rise Elevators	50	2	75%
Fire Pump	50	1	75%

AREAS		
TYPE	ft^2	m^2
Suites	134,293	12,476
Parking	38,955	3,619
Base building	24,173	2,246
TOTAL	197,420	18,341

SUITES				
TYPE	No.	AREA		
		ft^2	m^2	TOTAL (m^2)
1 Bed	65	703	65	4,245
2 Bed	74	959	89	6,593
3 Bed	12	1,469	137	1,638
TOTAL	151			12,476

SUITE LOADS (KW)							
TYPE	FIRST 45 m^2	NEXT 45 m^2	NEXT 90 m^2	NEXT 90 m^2	RANGE	DRYER @ 25%	LOAD (KW)
1 Bed	3.5	1.5	0.0	0	6	1.25	12.3
1 Bed + Den	3.5	1.5	0.0	0	6	1.25	12.3
2 Bed	3.5	1.5	1.0	0	6	1.25	13.3

RESIDENTIAL	
ITEM	LOAD (KW)
first suite @ 100%	13.3
2^{nd} & 3^{rd} @ 65%	17.2
4^{th} & 5^{th} @ 40%	10.6
6^{th} - 20^{th} @25%	47.7
remainder @10%	160.5
Mechanical (@55W/m^2)	686.2
TOTAL	935

EQUIPMENT		
ITEM	DEMAND FACTOR	LOAD (KW)
High Rise Elevators	50%	49.7
Fire Pump	100%	49.7
TOTAL		99.4

BASE BUILDING		
ITEM	W/m^2	LOAD (KW)
Basic allowance	30	67.4
Mechanical	55	123.5
TOTAL		190.9

PARKING		
ITEM	W/m^2	LOAD (KW)
Basic allowance	10	36.2
Mechanical	30	108.6
TOTAL		144.8

PARKING STALLS	
TYPE	TOTAL
Resident	119
Visitor	38
TOTAL	157

EV CHARGING AND TOTAL LOAD				
OPTION	TOTAL EV-READY CCT	DEMAND	TOTAL EV CHARGING POWER (KW)	TOTAL BUILDING LOAD (KW)
BUILDING ONLY				
Building Only			—	1,371
RESIDENTIAL EV CHARGING OPTIONS				
C1. Dedicated circuits on 40A, TGS	24	70%	116	1,487
C2. 3-share on 40A, TGS	8	100%	60	1,430
C3. Dedicated circuits on 40A, 100% EV R	119	100%	799	2,169
C5. 4-share on 40A, 100% EV Ready	30	100%	200	1,570
C6. 10-share on 80A, 100% EV Ready	12	100%	160	1,530
C7. 4-share on 40A, 100% EV Ready with service monitoring	30	0%	0	1,371

ARCHETYPE 3: TOWNHOUSE

GENERAL	
Space heating	gas furnace + HRV
Range	electric
Air-conditioning	all suites

AREAS		
TYPE	ft^2	m^2
Townhomes	62,100	5,769
TOTAL	62,100	5,769

UNITS				
TYPE	No.	AREA		
		ft^2	m^2	TOTAL (m^2)
MODEL 1	3	2,561	238	714
MODEL 1 END	2	2,635	245	490
MODEL 2	3	2,134	198	595
MODEL 2 END	1	2,197	204	204
MODEL 3	2	2,165	201	402
MODEL 4	1	2,695	250	250
MODEL 5	1	2,193	204	204
MODEL 6	1	2,145	199	199
MODEL 6 END	1	2,599	241	241
MODEL 7	1	2,684	249	249
MODEL 8	3	2,732	254	761
MODEL 9	3	2,077	193	579
MODEL 9 END	4	2,368	220	880
	26			5,769

UNIT LOADS (KW)							
TYPE	FIRST 90 m^2	NEXT 90 m^2	NEXT 90 m^2	NEXT 90 m^2	RANGE	DRYER @ 25%	LOAD (KW)
MODEL 1	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 1 END	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 2	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 2 END	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 3	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 4	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 5	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 6	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 6 END	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 7	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 8	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 9	5.0	1.0	1.0	0.0	6	1.25	14.3
MODEL 9 END	5.0	1.0	1.0	0.0	6	1.25	14.3

RESIDENTIAL	
ITEM	LOAD (KW)
first suite @ 100%	14.3
2^{nd} & 3^{rd} @ 65%	18.5
4^{th} & 5^{th} @ 40%	11.4
6^{th} - 20^{th} @25%	53.4
remainder @10%	8.6
Mechanical (@10W/m^2)	57.7
TOTAL	163.9

PARKING STALLS	
TYPE	TOTAL
Resident	52
Visitor	5
TOTAL	57

EV CHARGING AND TOTAL LOAD				
OPTION	TOTAL EV-READY CCT	DF	TOTAL EV CHARGING POWER (KW)	TOTAL BUILDING LOAD (KW)
BUILDING ONLY				
Building Only			—	164
RESIDENTIAL EV CHARGING OPTIONS				
C1. 2-share on 40A. 100% EV Ready	26	70%	126	290
C2. Service Monitoring, 100% EV Ready	26	0%	0	164
C3. Load Miser,	26	0%	0	164

ARCHETYPE 3: TOWNHOUSE - PER DWELLING

GENERAL	
Space heating	gas furnace + HRV
Range	electric
Air-conditioning	all suites

AREAS		
TYPE	ft^2	m^2
Townhomes	2,635	245
TOTAL	2,635	245

UNITS				
TYPE	No.	AREA		
		ft^2	m^2	TOTAL (m^2)
MODEL 1 END	1	2,635	245	245
	1			245

UNIT LOADS (KW)							
TYPE	FIRST 90 m^2	NEXT 90 m^2	NEXT 90 m^2	NEXT 90 m^2	RANGE	DRYER @ 25%	LOAD (KW)
MODEL 1 END	5.0	1.0	1.0	0.0	6	1.25	14.3

RESIDENTIAL	
ITEM	LOAD (KW)
first suite @ 100%	14.3
2nd & 3rd @ 65%	
4th & 5th @ 40%	
6th - 20th @25%	
remainder @10%	
Mechanical (@10W/m^2)	2.4
TOTAL	16.7

PARKING STALLS	
TYPE	TOTAL
Resident	1
Visitor	0
TOTAL	1

EV CHARGING AND TOTAL LOAD				
OPTION	TOTAL EV-READY CCT	DF	TOTAL EV CHARGING POWER (KW)	TOTAL BUILDING LOAD (KW)
BUILDING ONLY				
Building Only			—	17
RESIDENTIAL EV CHARGING OPTIONS				
C1. 2-share on 40A. 100% EV Ready	1	70%	9	26
C2. Service Monitoring, 100% EV Ready	1	0%	0	17
C3. Load Miser,	1	0%	0	17

ARCHETYPE 4: SINGLE FAMILY HOME

GENERAL	
Space heating	gas furnace + HRV
Range	electric
Air-conditioning	all suites

AREAS		
TYPE	ft^2	m^2
Suites	55,706	5,175
TOTAL	55,706	5,175

UNITS				
TYPE	No.	AREA		
		ft^2	m^2	TOTAL (m^2)
3 STOREY HOME	22	2,532	235	5,175
	22			5,175

UNIT LOADS (KW)							
TYPE	FIRST 90 m^2	NEXT 90 m^2	NEXT 90 m^2	RANGE	DRYER @ 25%	A/C	LOAD
3 STOREY HOME	5.0	1.0	1.0	6	1.25	3.5	17.8

RESIDENTIAL	
ITEM	LOAD (KW)
first suite @ 100%	17.8
2nd & 3rd @ 65%	23.1
4th & 5th @ 40%	14.2
6th - 20th @25%	66.6
remainder @10%	3.6
Mechanical (@10W/m^2)	51.8
TOTAL	176.9

PARKING STALLS	
TYPE	TOTAL
Resident	44
Visitor	7
TOTAL	51

EV CHARGING AND TOTAL LOAD				
OPTION	TOTAL EV-READY CCT	DEMAND	TOTAL EV CHARGING POWER (KW)	TOTAL SUBDIVISION LOAD (KW)
BUILDING ONLY				
Building Only			—	177
RESIDENTIAL EV CHARGING OPTIONS				
C1. 2-share on 40A. 100% EV Ready	22	70%	107	284
C2. Load Switching,	22	0%	0	177

ARCHETYPE 4: SINGLE FAMILY HOME - PER DWELLING

GENERAL	
Space heating	gas furnace + HRV
Range	electric
Air-conditioning	all suites

AREAS		
TYPE	ft^2	m^2
Suites	2,532	235
TOTAL	2,532	235

UNITS				
TYPE	No.	AREA		
		ft^2	m^2	TOTAL (m^2)
3 STOREY HOME	1	2,532	235	235
	1			235

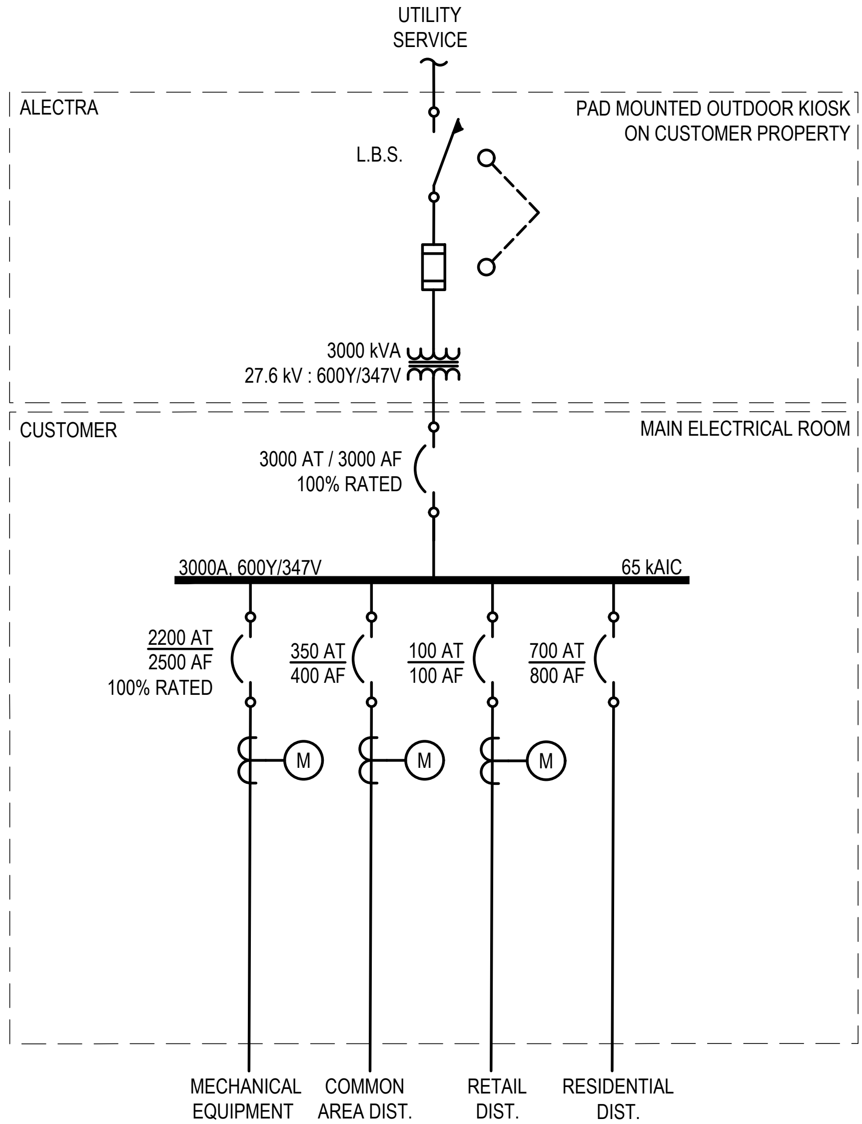
UNIT LOADS (KW)							
TYPE	FIRST 90 m^2	NEXT 90 m^2	NEXT 90 m^2	RANGE	DRYER @ 25%	A/C	LOAD
3 STOREY HOME	5.0	1.0	1.0	6	1.25	3.5	17.8

RESIDENTIAL	
ITEM	LOAD (KW)
first suite @ 100%	17.8
2nd & 3rd @ 65%	
4th & 5th @ 40%	
6th - 20th @25%	
remainder @10%	
Mechanical (@10W/m^2)	2.4
TOTAL	20.1

PARKING STALLS	
TYPE	TOTAL
Resident	1
Visitor	0
TOTAL	1

EV CHARGING AND TOTAL LOAD				
OPTION	TOTAL EV-READY CCT	DEMAND	TOTAL EV CHARGING POWER (KW)	TOTAL SUBDIVISION LOAD (KW)
BUILDING ONLY				
Building Only			—	20
RESIDENTIAL EV CHARGING OPTIONS				
C1. 2-share on 40A. 100% EV Ready	1	70%	9	29
C2. Service Monitoring,	1	0%	0	20

Appendix B: Single line diagrams



consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

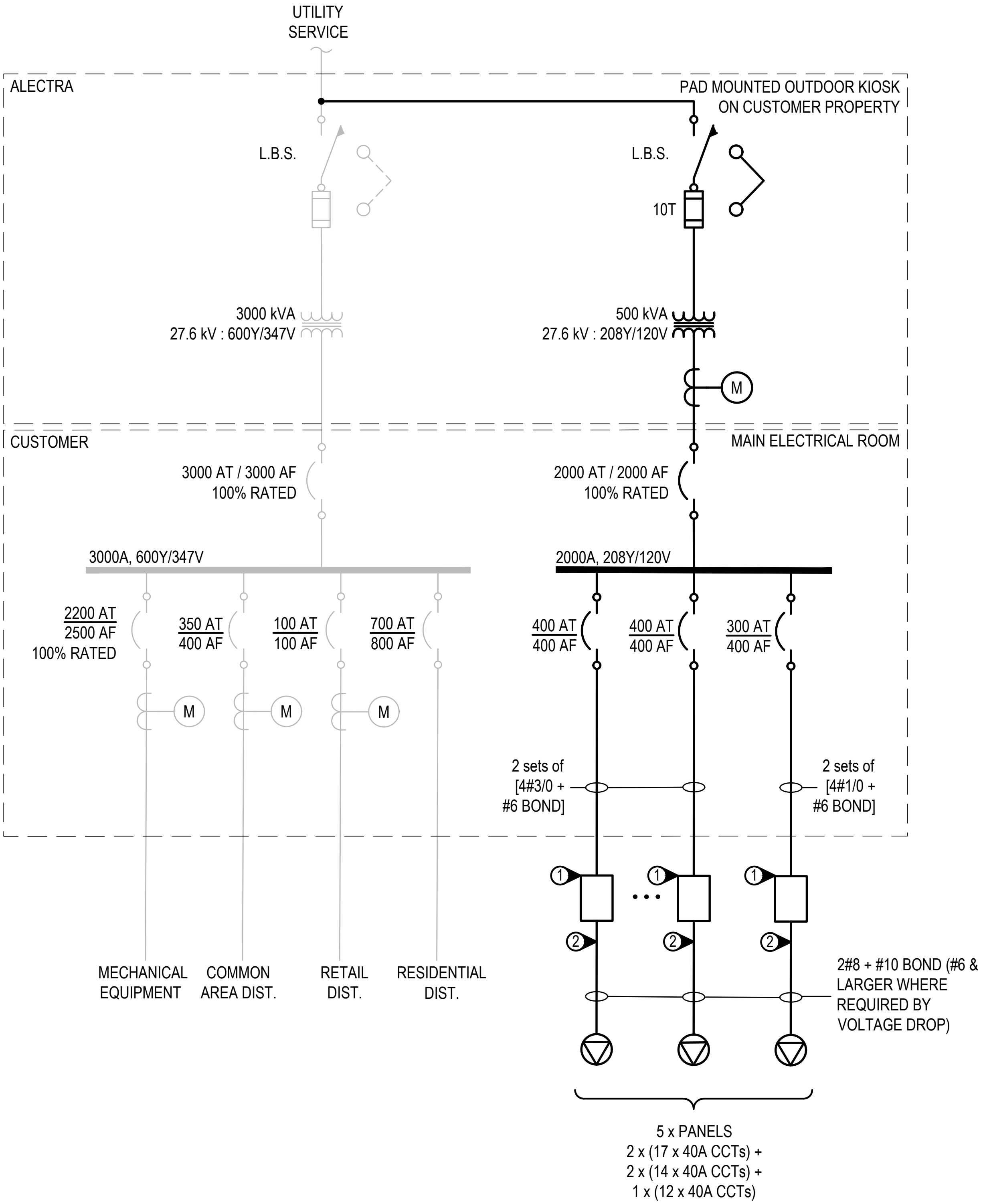
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

HIGH RISE
BASELINE

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-00	3



KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 1 EV STALL PER 40 A, 208V, 2P BRANCH CIRCUIT

GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 74
B) TOTAL EVSE OUTLETS: 74

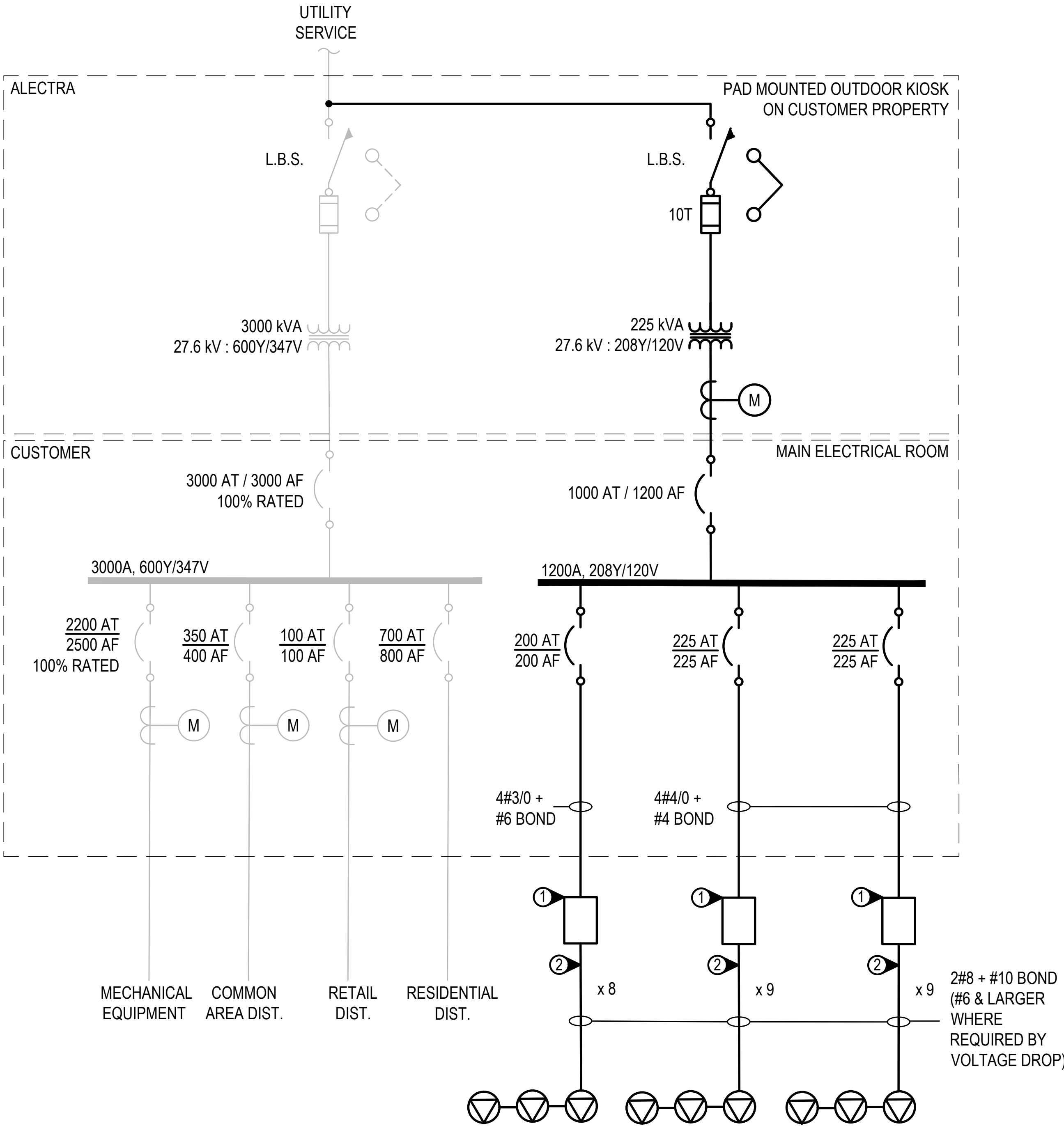
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title
HIGH RISE
C1. DEDICATED CIRCUITS ON 40A, TGS.v3

designed TE	scale AS NOTED	date	
drawn TE	project no. 2-21-050		
checked	drawing no. E-01		rev. 3
approved			



KEYNOTES:

1. 225A, 208Y/120V 42 CCT PANELBOARD
2. 3 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 26
B) TOTAL EVSE OUTLETS: 74

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

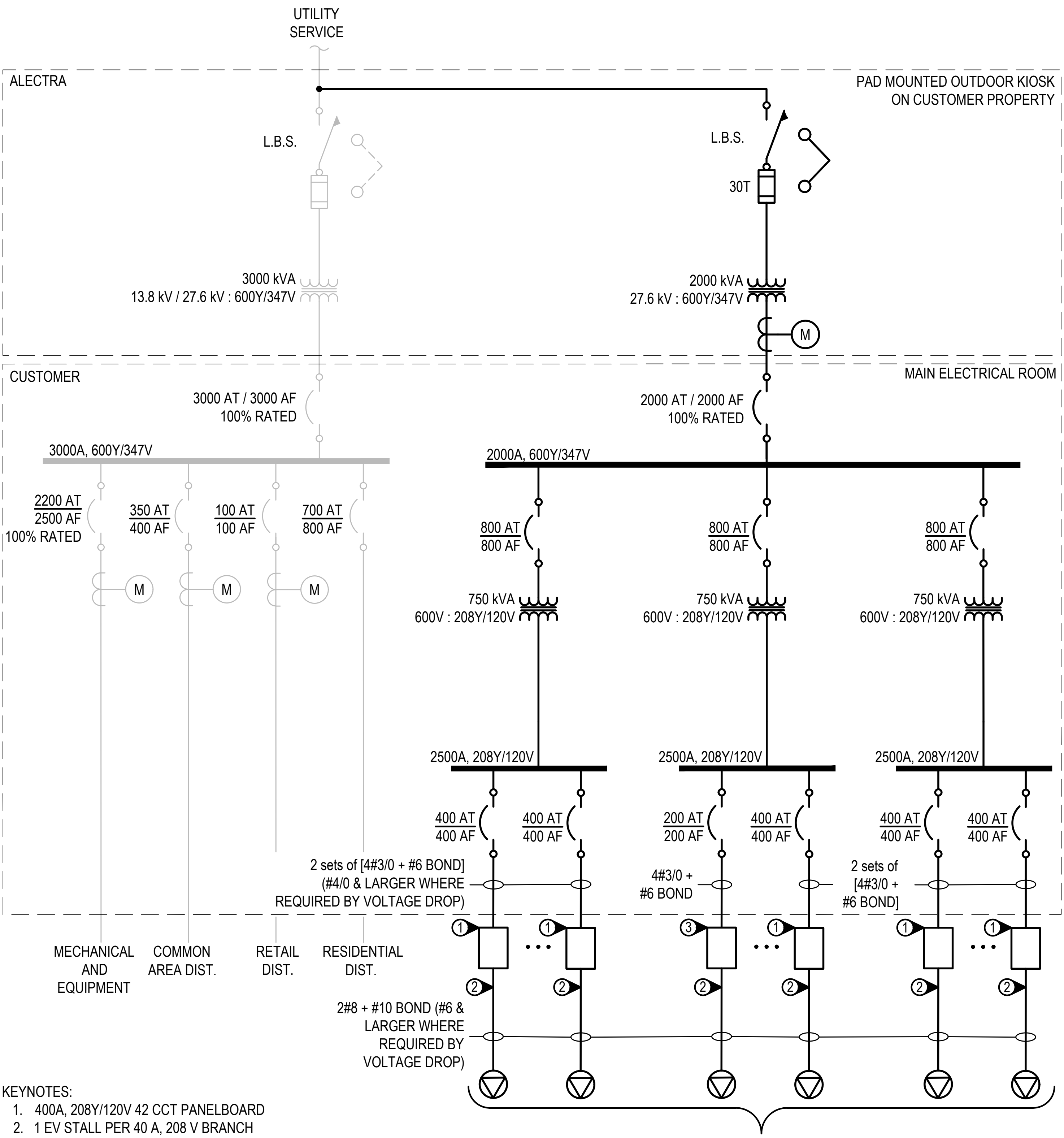
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

HIGH RISE
C2. 3-SHARE ON 40A, TGS.v3

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-02	3



24 x PANELS
15 x (17 x 40A CCTs) + 1 x (16 x 40A CCTs) +
3 x (15 x 40A CCTs) + 2 x (12 x 40A CCTs) +
1 x (11 x 40A CCTs) + 1 x (10 x 40A CCTs) +
1 x (8 x 40A CCTs) (225 A panel)

KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 1 EV STALL PER 40 A, 208 V BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:
A) TOTAL CIRCUITS: 369
B) TOTAL EVSE OUTLETS: 369

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

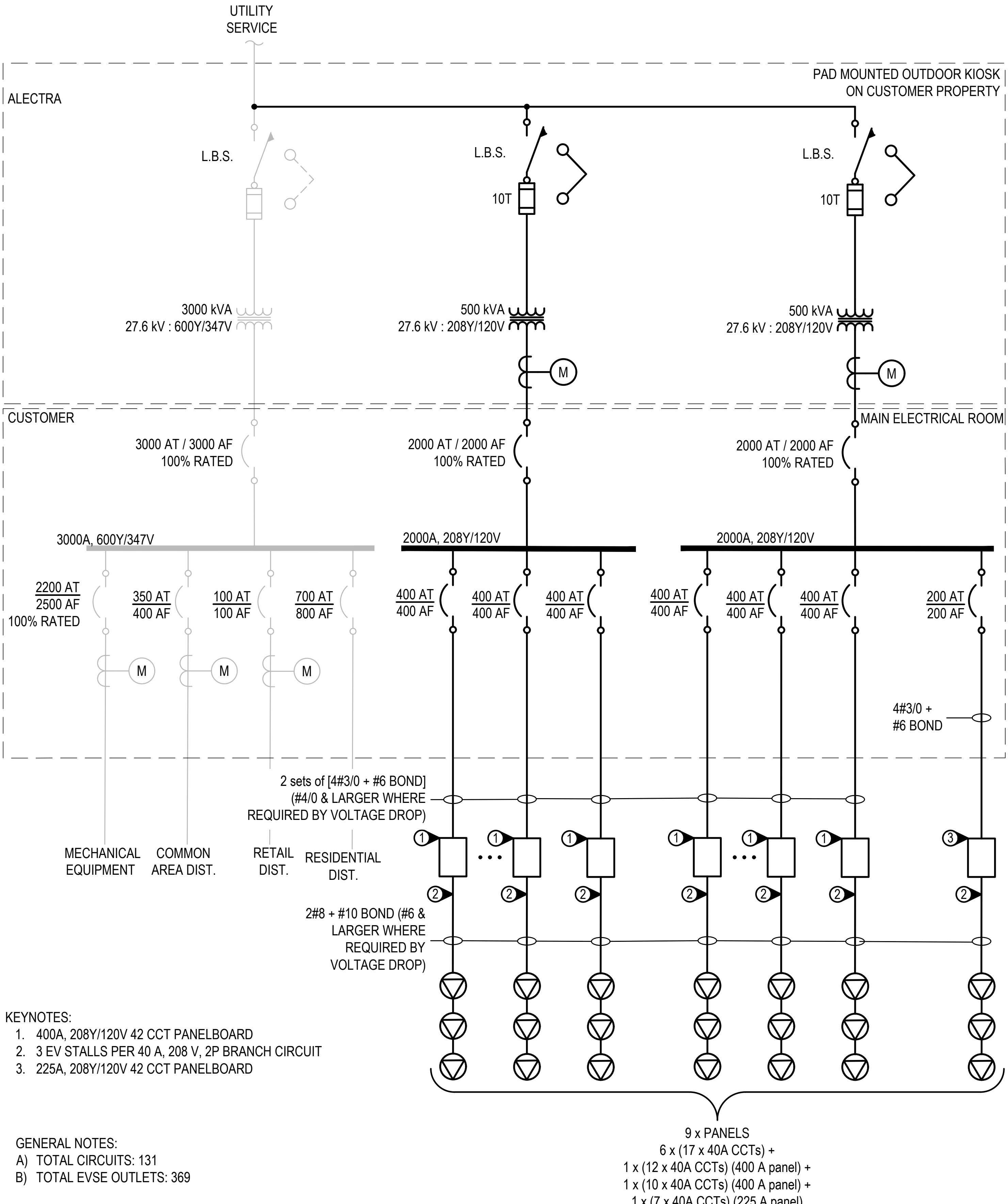
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

HIGH RISE
C3. DEDICATED CIRCUITS ON 40A, 100% EV READY

designed	scale	date	
TE	AS NOTED		
drawn	project no.		
TE	2-21-050		
checked	drawing no.		rev.
approved	E-03		3



KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 3 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:
A) TOTAL CIRCUITS: 131
B) TOTAL EVSE OUTLETS: 369

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

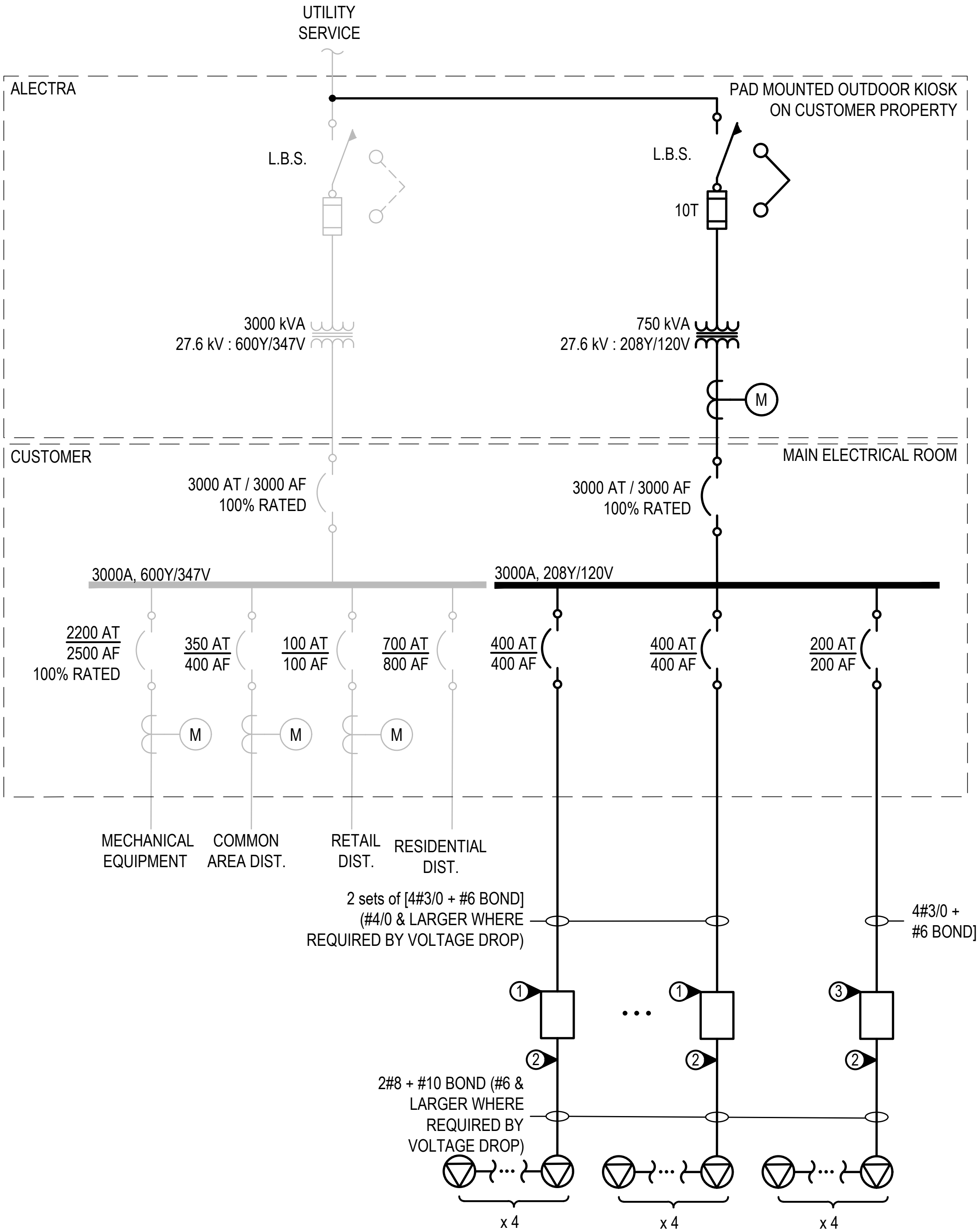
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

HIGH RISE
C4. 3-SHARE ON 40A, 100% EV READY

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-04	3



KEYNOTES:

1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 4 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 96
B) TOTAL EVSE OUTLETS: 369

consultant
AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

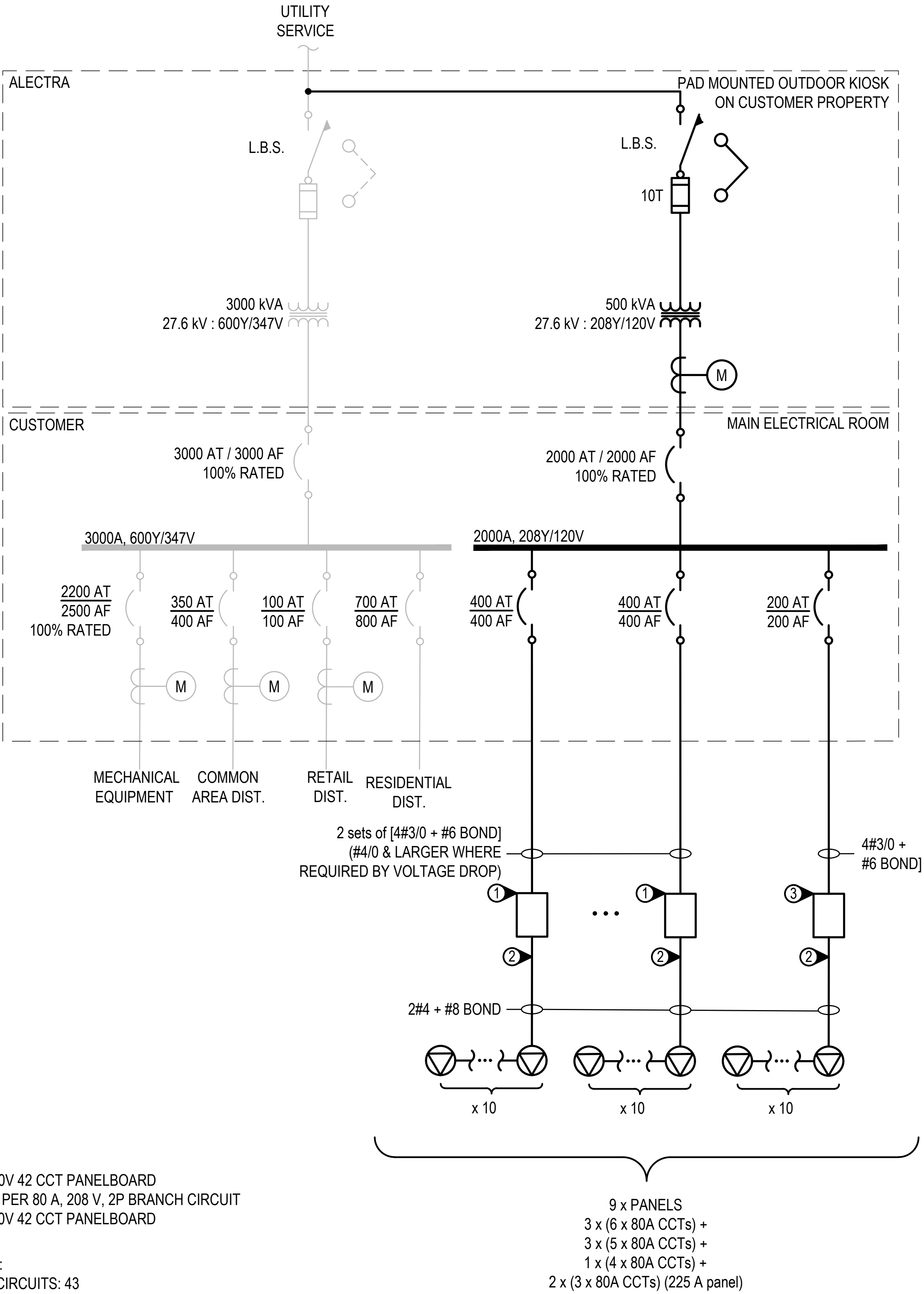
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

HIGH RISE
C5. 4-SHARE ON 40A, 100% EV READY

designed TE	scale AS NOTED	date
drawn TE	project no. 2-21-050	
checked	drawing no. E-05	rev. 3
approved		



KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 10 EV STALLS PER 80 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 43
B) TOTAL EVSE OUTLETS: 369

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

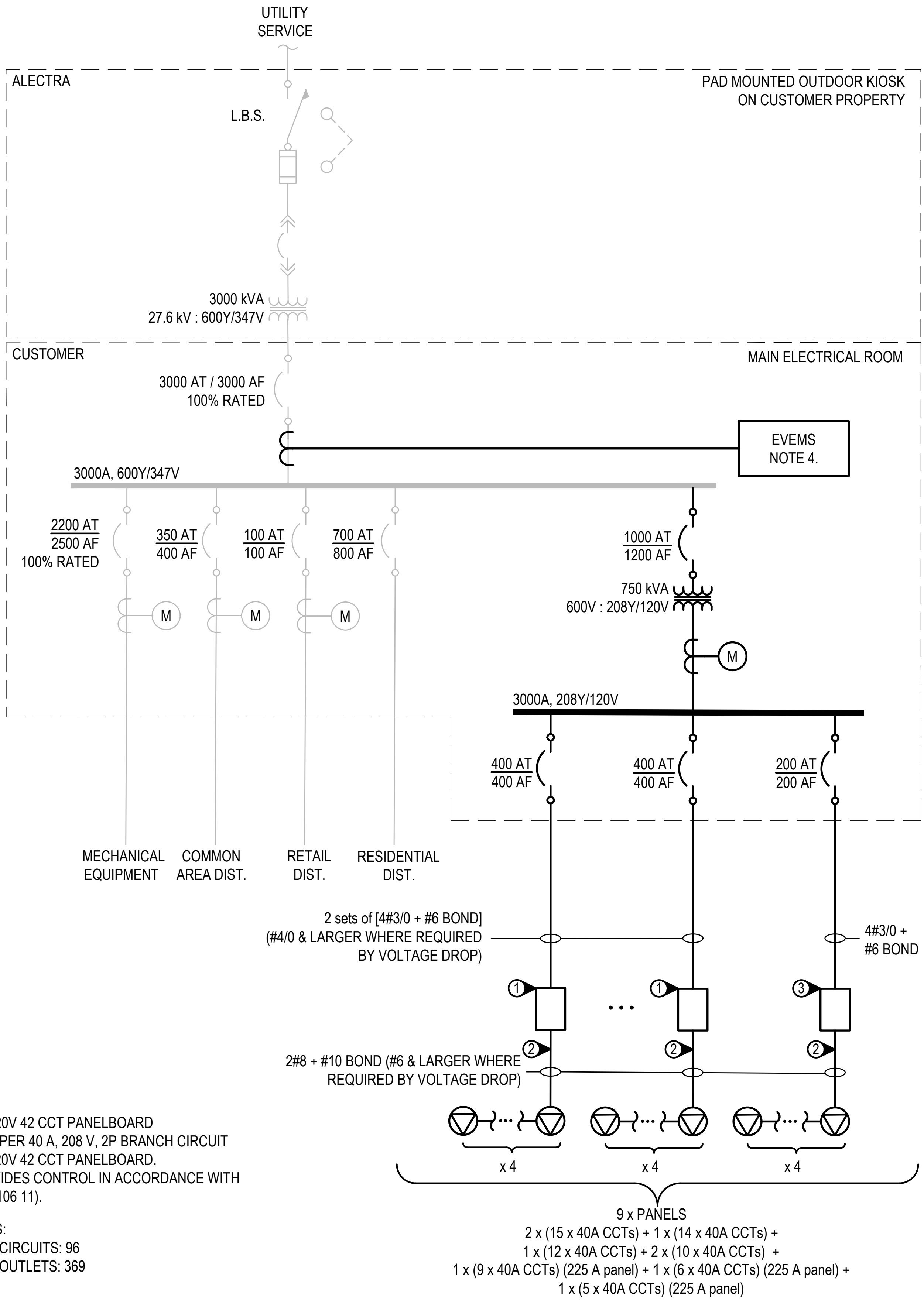
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

HIGH RISE
C6. 10-SHARE ON 80A, 100% EV READY

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-06	3



KEYNOTES:

1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 4 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD.
4. EVEMS PROVIDES CONTROL IN ACCORDANCE WITH CEC RULE 8-106 11).

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 96
B) TOTAL EVSE OUTLETS: 369

consultant

AES
Designing A Better Tomorrow

505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

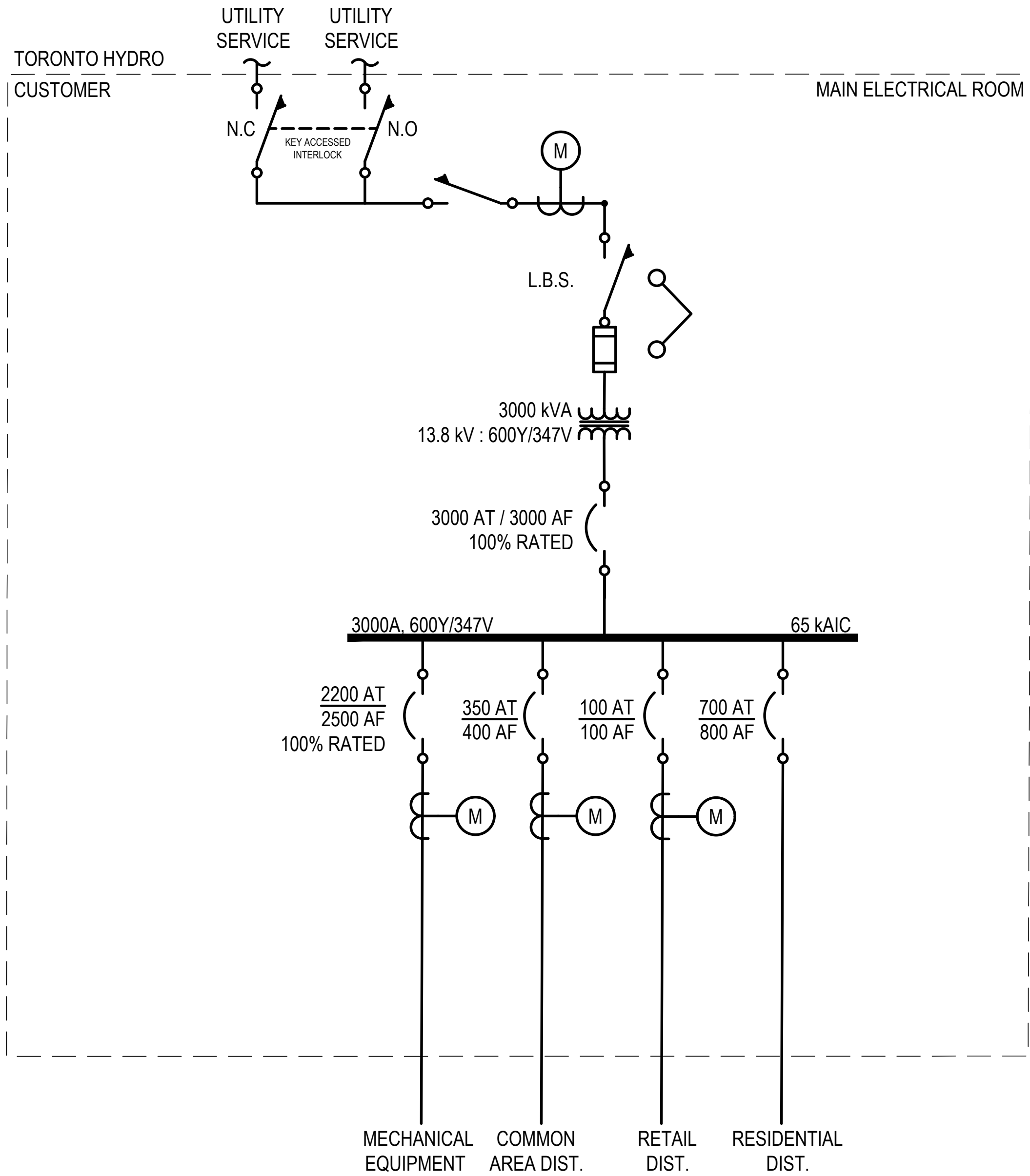
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

HIGH RISE
C7. 4-SHARE ON 40A, 100% EV READY
W/ SERVICE MONITORING

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-07	3



consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

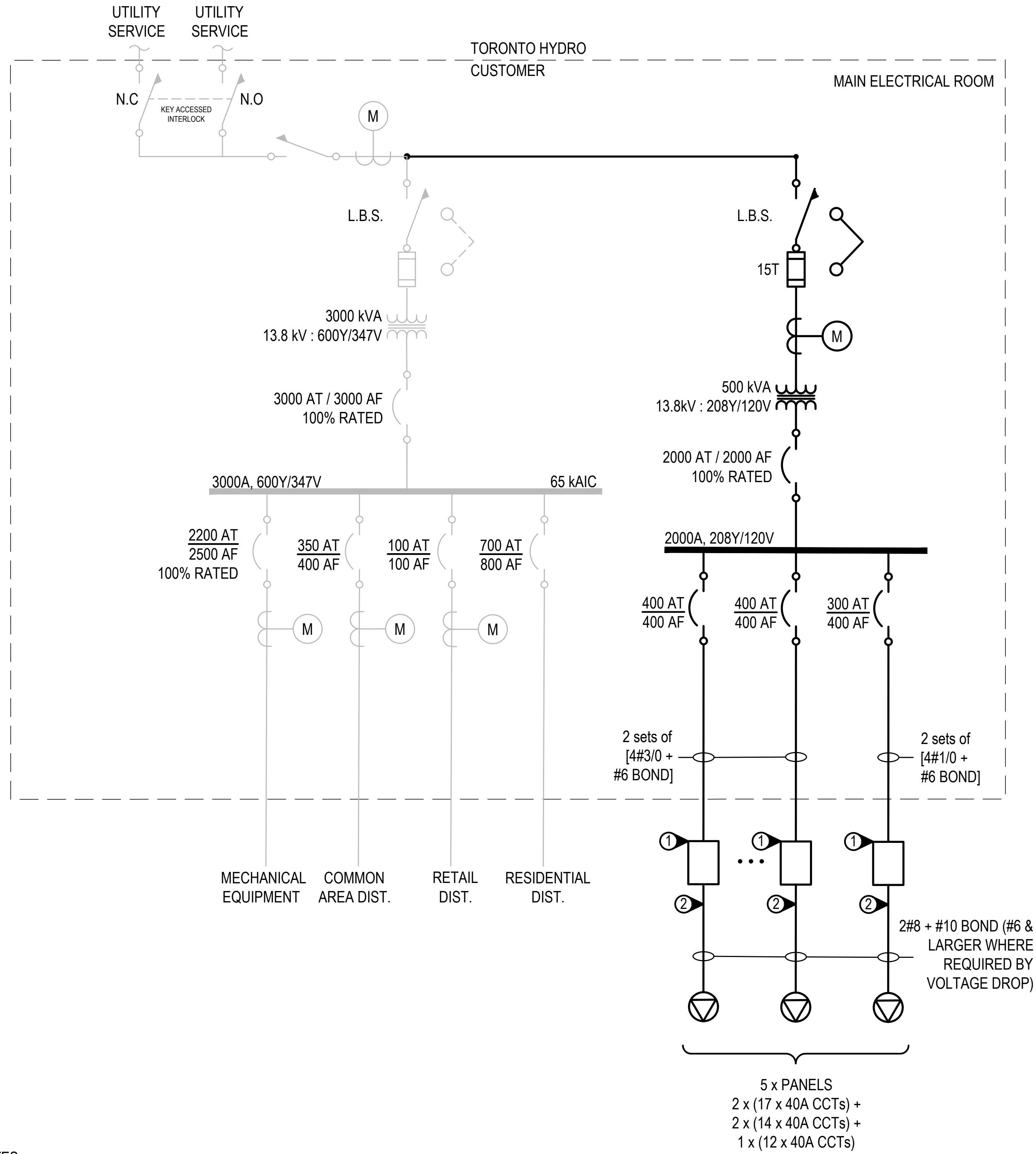
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TORONTO HIGH RISE
BASELINE

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-10	3



KEYNOTES:

1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 1 EV STALL PER 40 A, 208V, 2P BRANCH CIRCUIT

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 74
B) TOTAL EVSE OUTLETS: 74

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

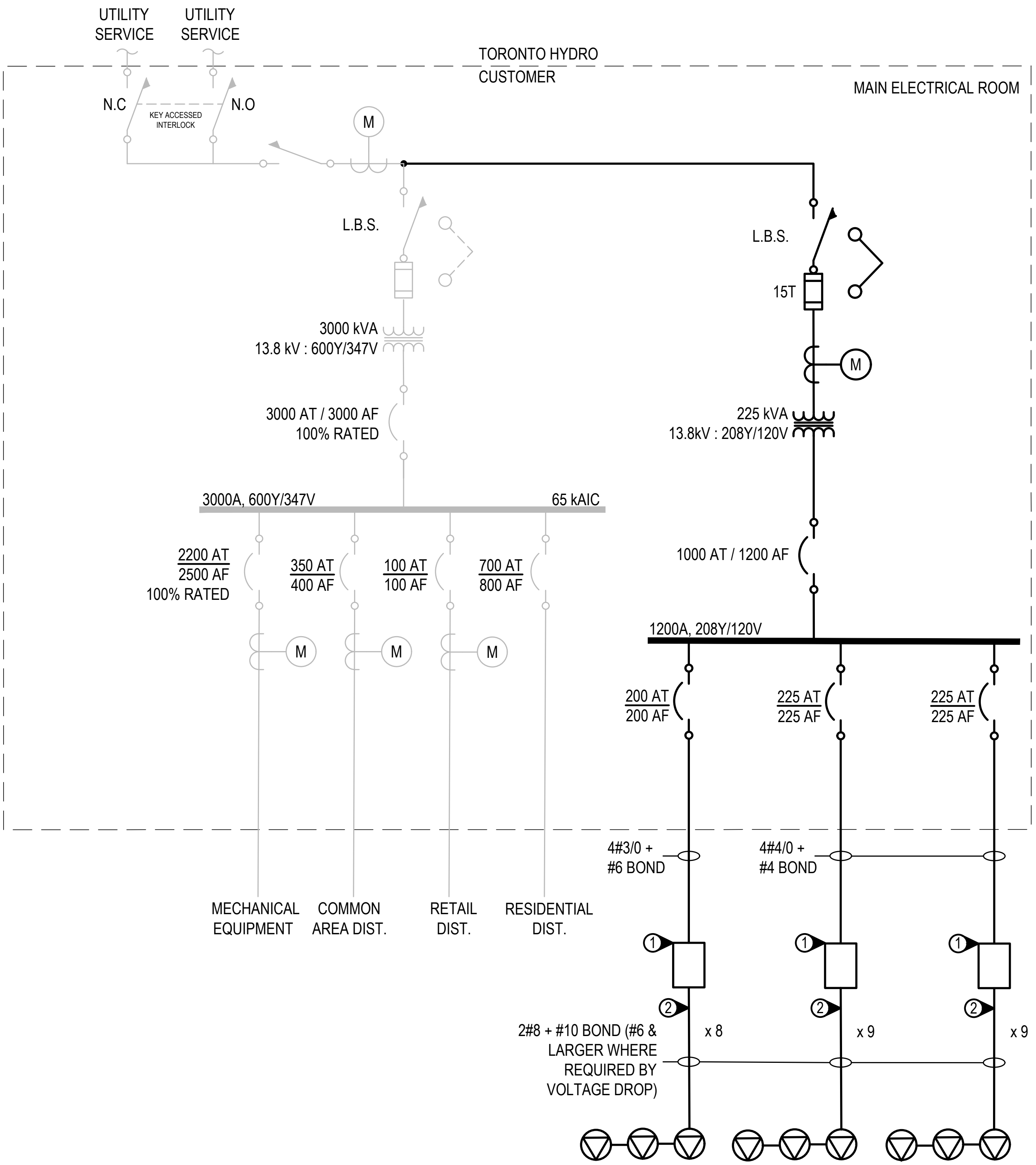
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TORONTO HIGH RISE
C1. DEDICATED CIRCUITS ON 40 A, TGS.v3

designed TE	scale AS NOTED	date	
drawn TE	project no. 2-21-050		
checked	drawing no.		rev.
approved	E-11		3



KEYNOTES:
1. 225A, 208Y/120V 42 CCT PANELBOARD
2. 3 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT

GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 26
B) TOTAL EVSE OUTLETS: 74

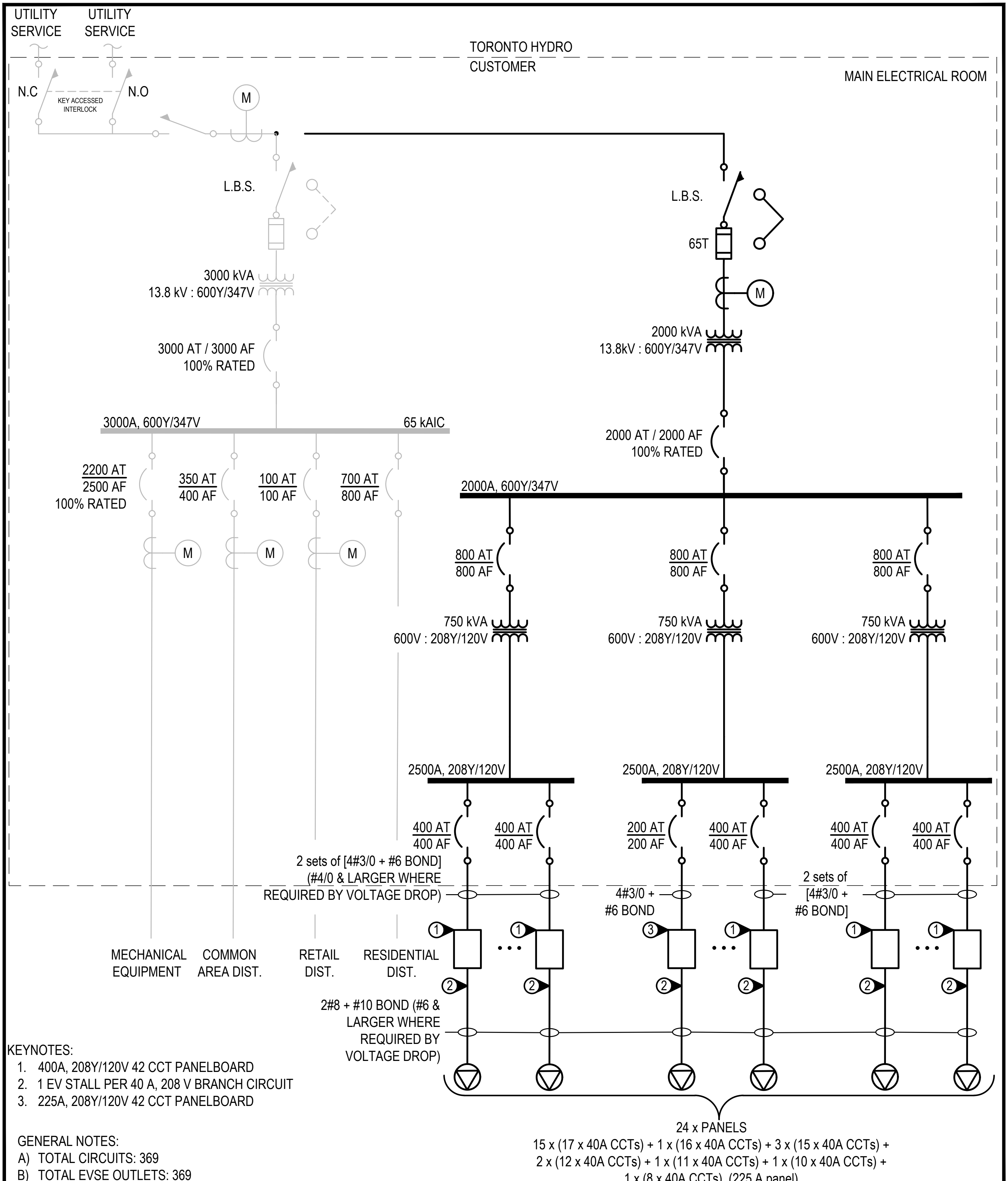
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title
TORONTO HIGH RISE
C2. 3-SHARE ON 40A, TGS.v3

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-12	3



KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 1 EV STALL PER 40 A, 208 V BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:
A) TOTAL CIRCUITS: 369
B) TOTAL EVSE OUTLETS: 369

consultant

AES
Designing A Better Tomorrow

505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

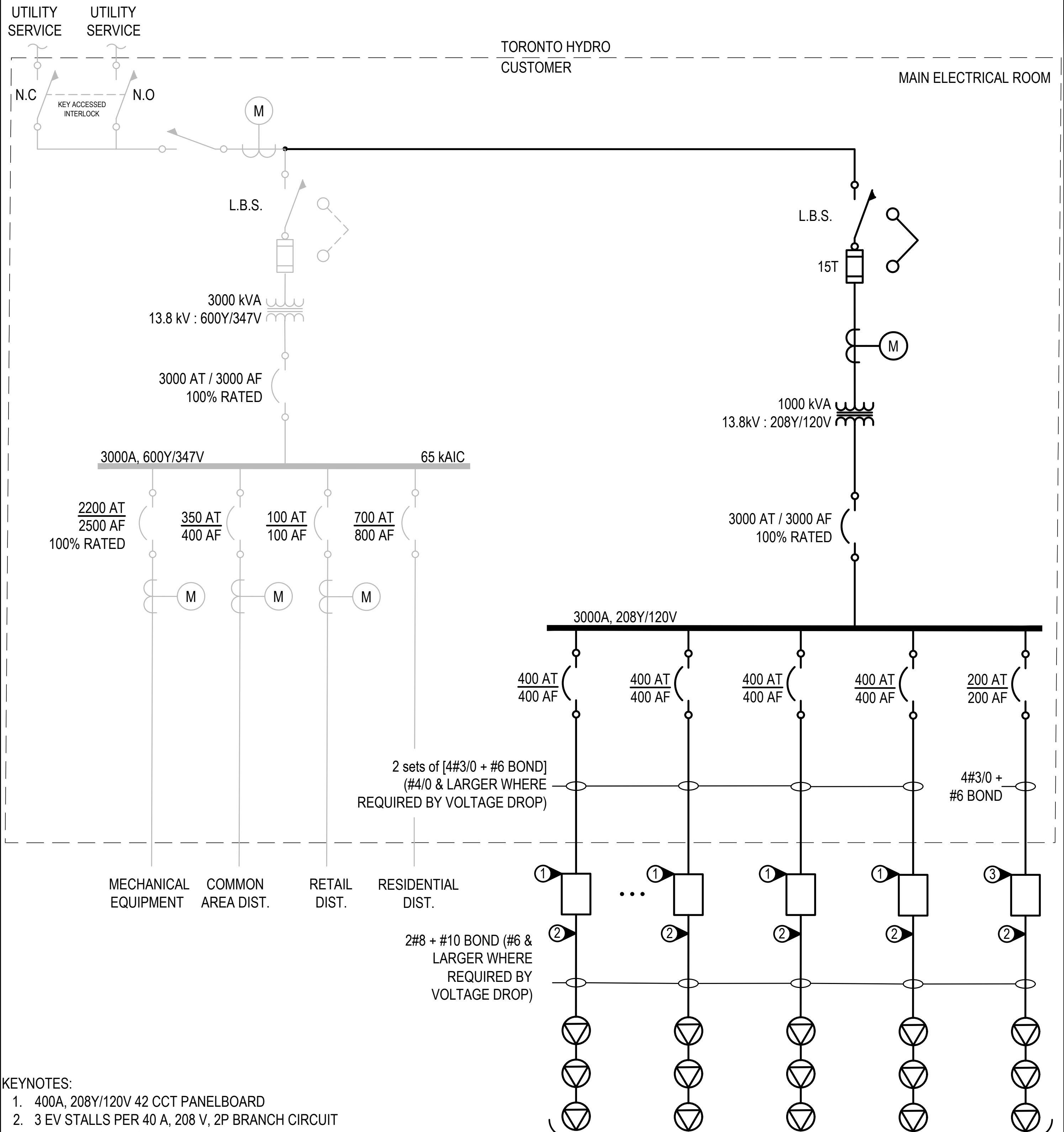
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TORONTO HIGH RISE
C3. DEDICATED CIRCUITS ON 40 A, 100% EV READY

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-13	3



9 x PANELS
6 x (17 x 40A CCTs) +
1 x (12 x 40A CCTs) (400 A panel) +
1 x (10 x 40A CCTs) (400 A panel) +
1 x (7 x 40A CCTs) (225 A panel)

KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 3 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:
A) TOTAL CIRCUITS: 131
B) TOTAL EVSE OUTLETS: 369

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

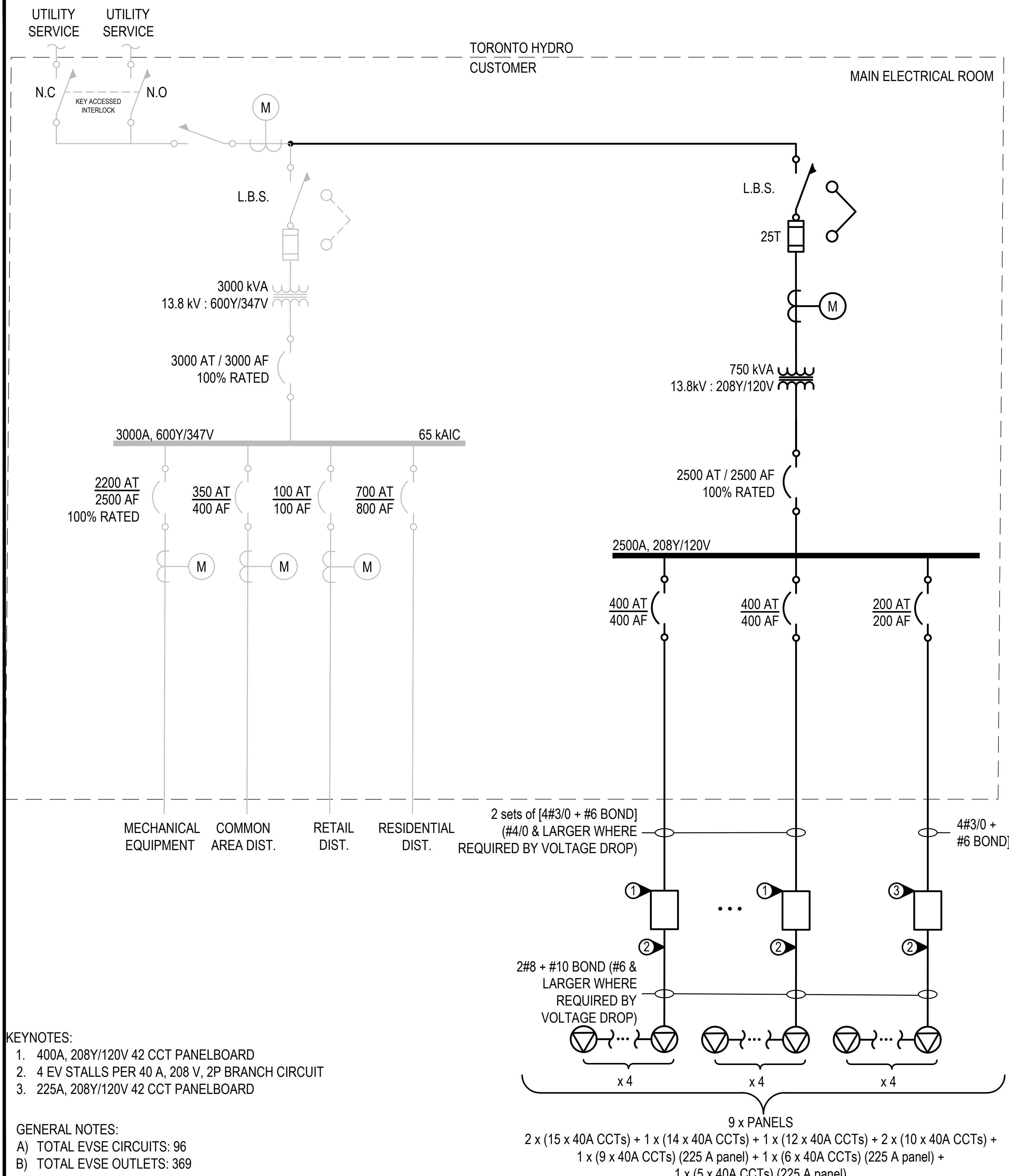
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TORONTO HIGH RISE
C4. 3-SHARE ON 40A, 100% EV READY

designed TE	scale AS NOTED	date
drawn TE	project no. 2-21-050	
checked	drawing no. E-14	rev. 3
approved		



KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 4 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

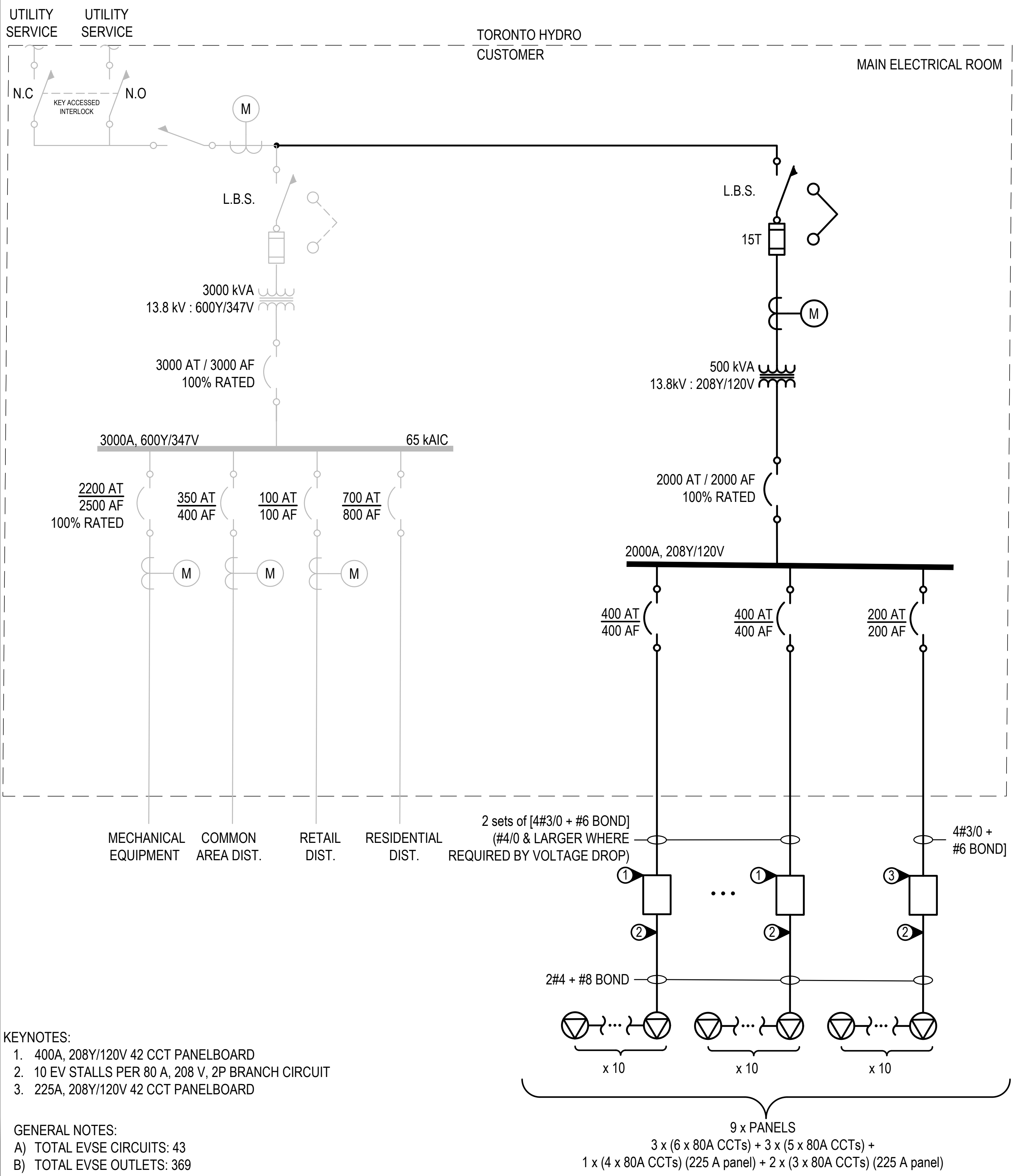
GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 96
B) TOTAL EVSE OUTLETS: 369

consultant
AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title
TORONTO HIGH RISE
C5. 4-SHARE ON 40 A, 100% EV READY

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-15	3



KEYNOTES:
1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 10 EV STALLS PER 80 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD

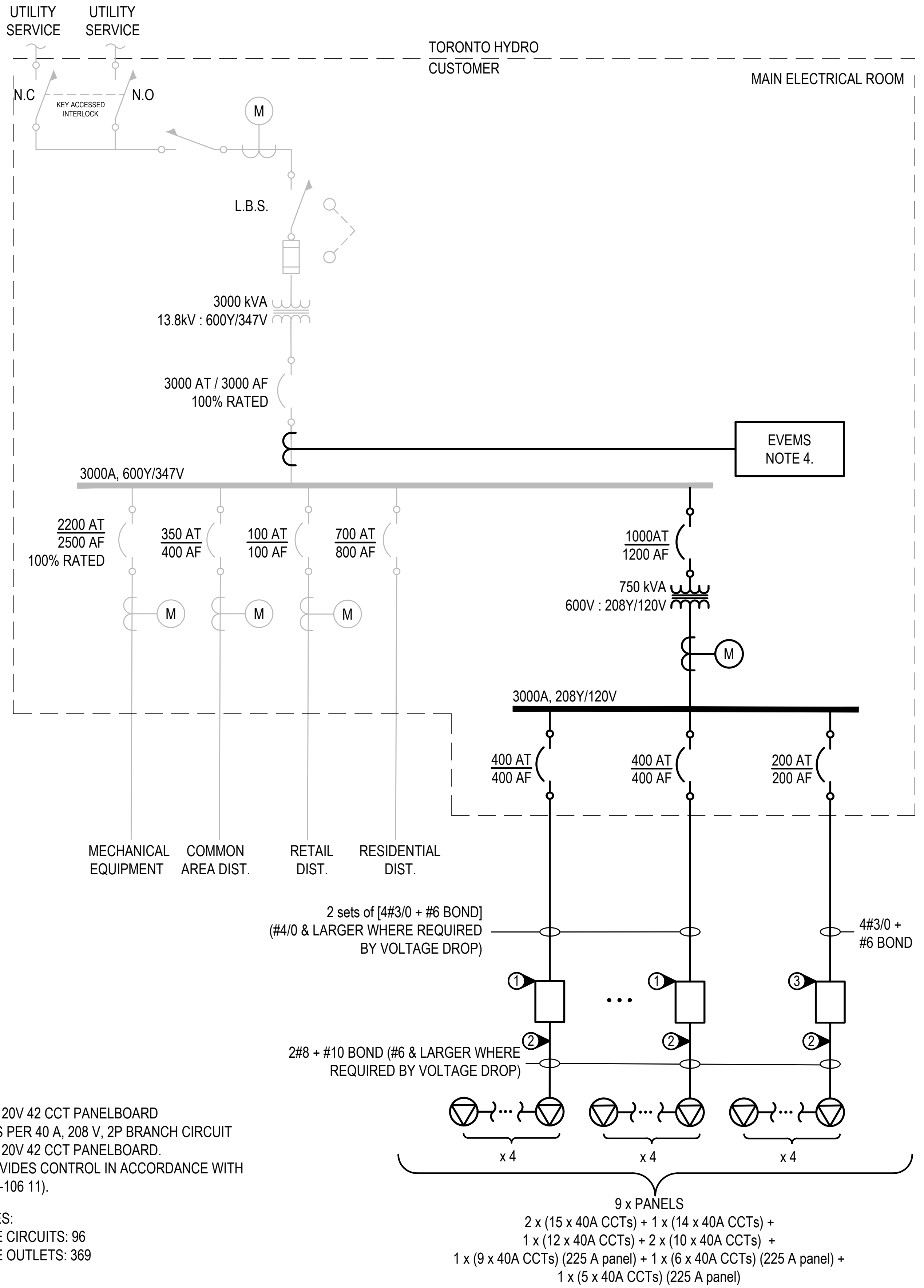
GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 43
B) TOTAL EVSE OUTLETS: 369

consultant
AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title
TORONTO HIGH RISE
C6. 10-SHARE ON 80 A, 100% EV READY

designed TE	scale AS NOTED	date
drawn TE	project no. 2-21-050	
checked	drawing no. E-16	rev. 3
approved		



KEYNOTES:

1. 400A, 208Y/120V 42 CCT PANELBOARD
2. 4 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT
3. 225A, 208Y/120V 42 CCT PANELBOARD.
4. EVEMS PROVIDES CONTROL IN ACCORDANCE WITH CEC RULE 8-106 11).

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 96
B) TOTAL EVSE OUTLETS: 369

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

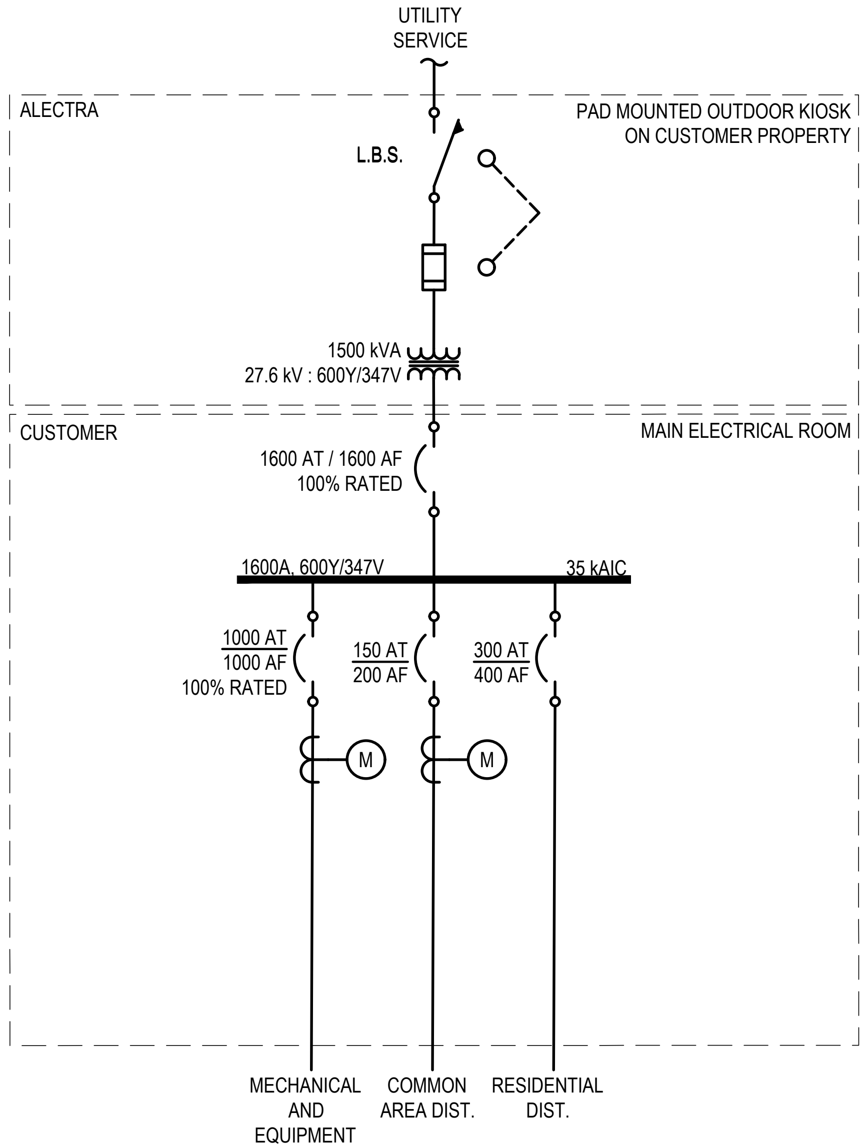
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TORONTO HIGH RISE
C7. 4-SHARE ON 40 A, 100% EV READY
W/ SERVICE MONITORING

designed TE	scale AS NOTED	date
drawn TE	project no. 2-21-050	
checked	drawing no. E-17	rev. 3
approved		



consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

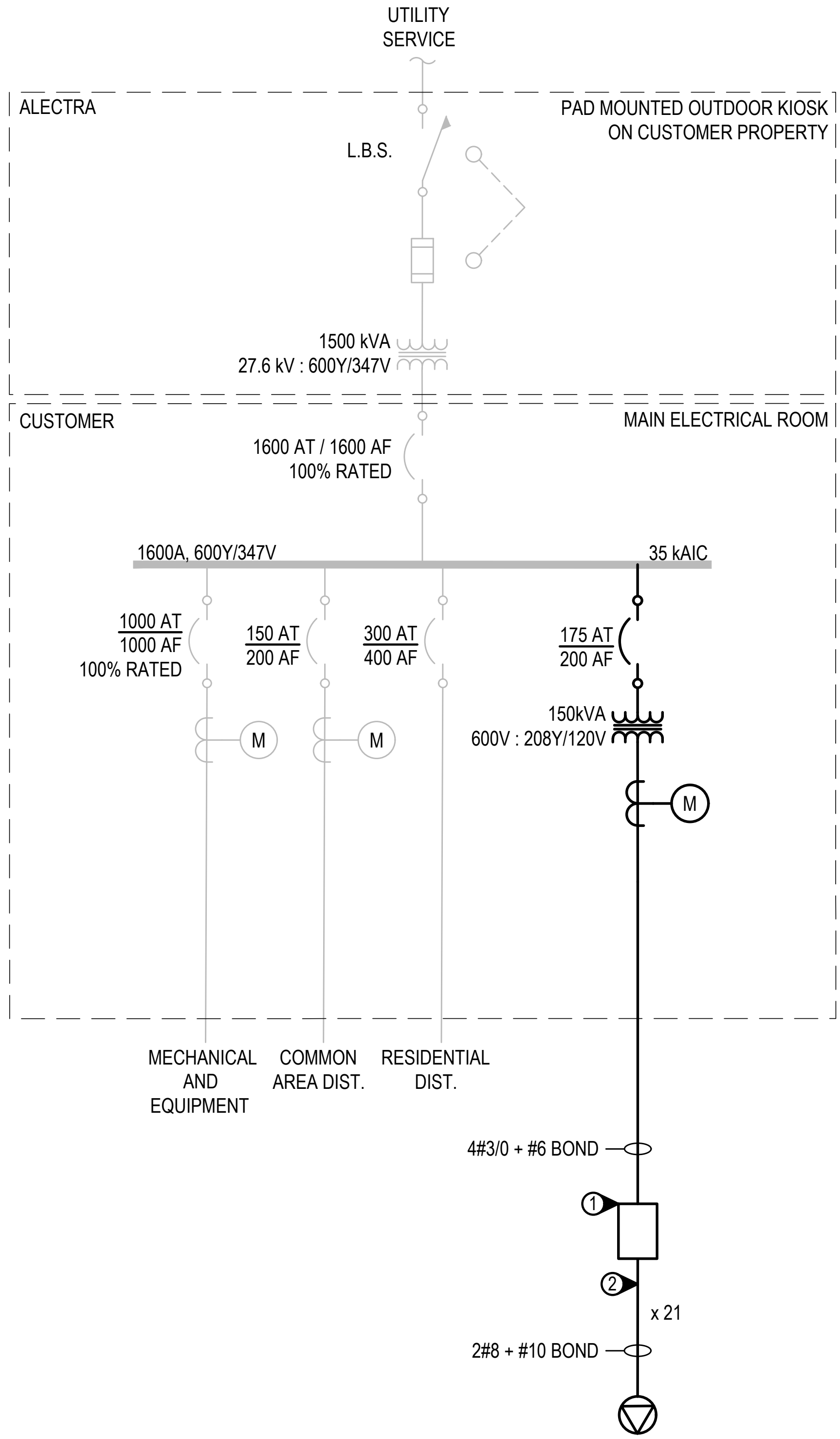
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

MID RISE
BASELINE

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-20	3



KEYNOTES:

1. 600A, 208Y/120V 42 CCT PANELBOARD
2. 1 EV STALL PER 40 A, 208 V, 2P BRANCH CIRCUIT

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 21
B) TOTAL EVSE OUTLETS: 21

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

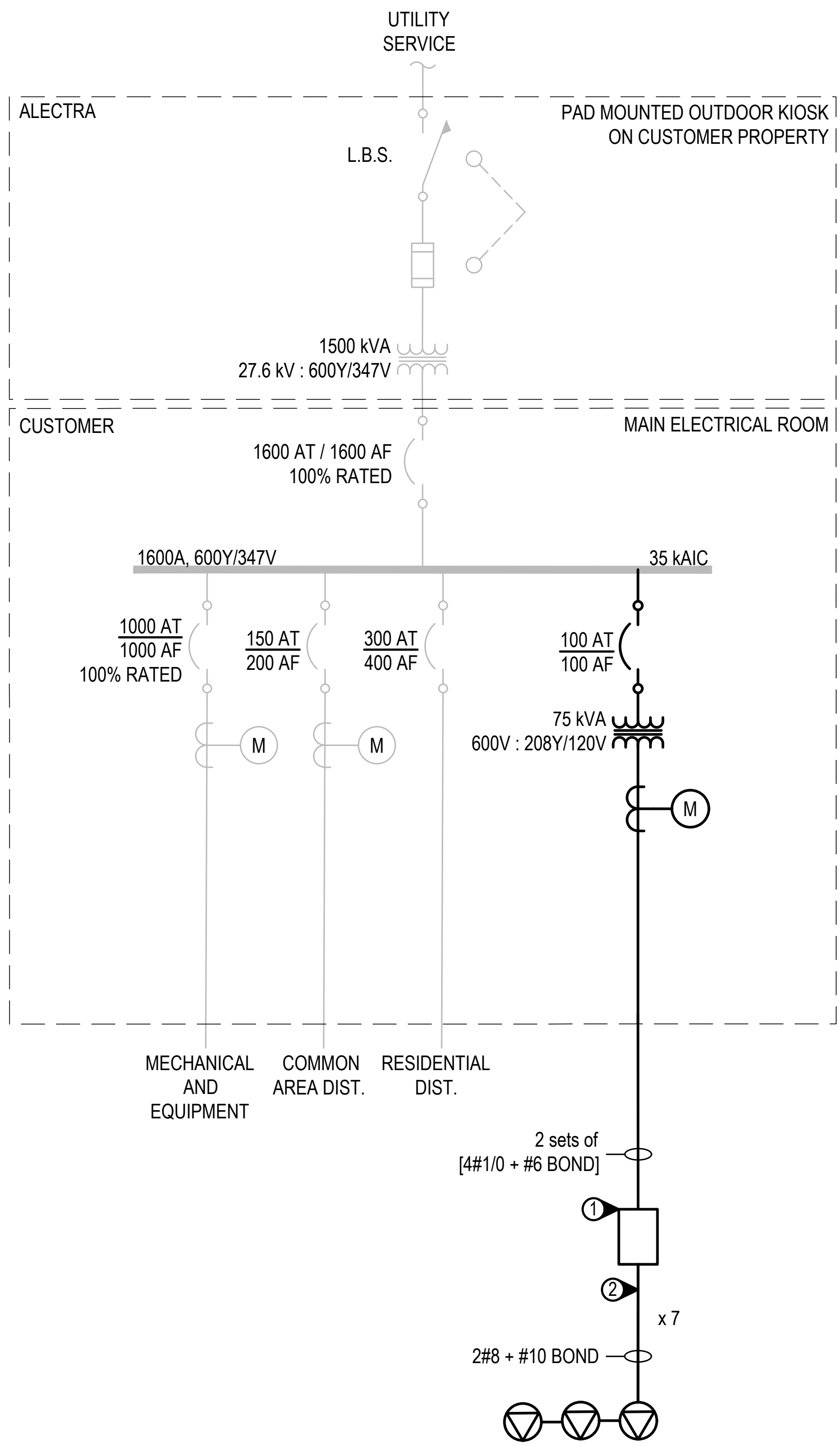
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

MID RISE
C1. DEDICATED CIRCUITS ON 40A, TGS.v3

designed TE	scale AS NOTED	date	
drawn TE	project no. 2-21-050		
checked	drawing no. E-21	rev. 3	
approved			



KEYNOTES:

1. 225 A, 208Y/120V 42 CCT PANELBOARD
2. 3 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 7
B) TOTAL EVSE OUTLETS: 21

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

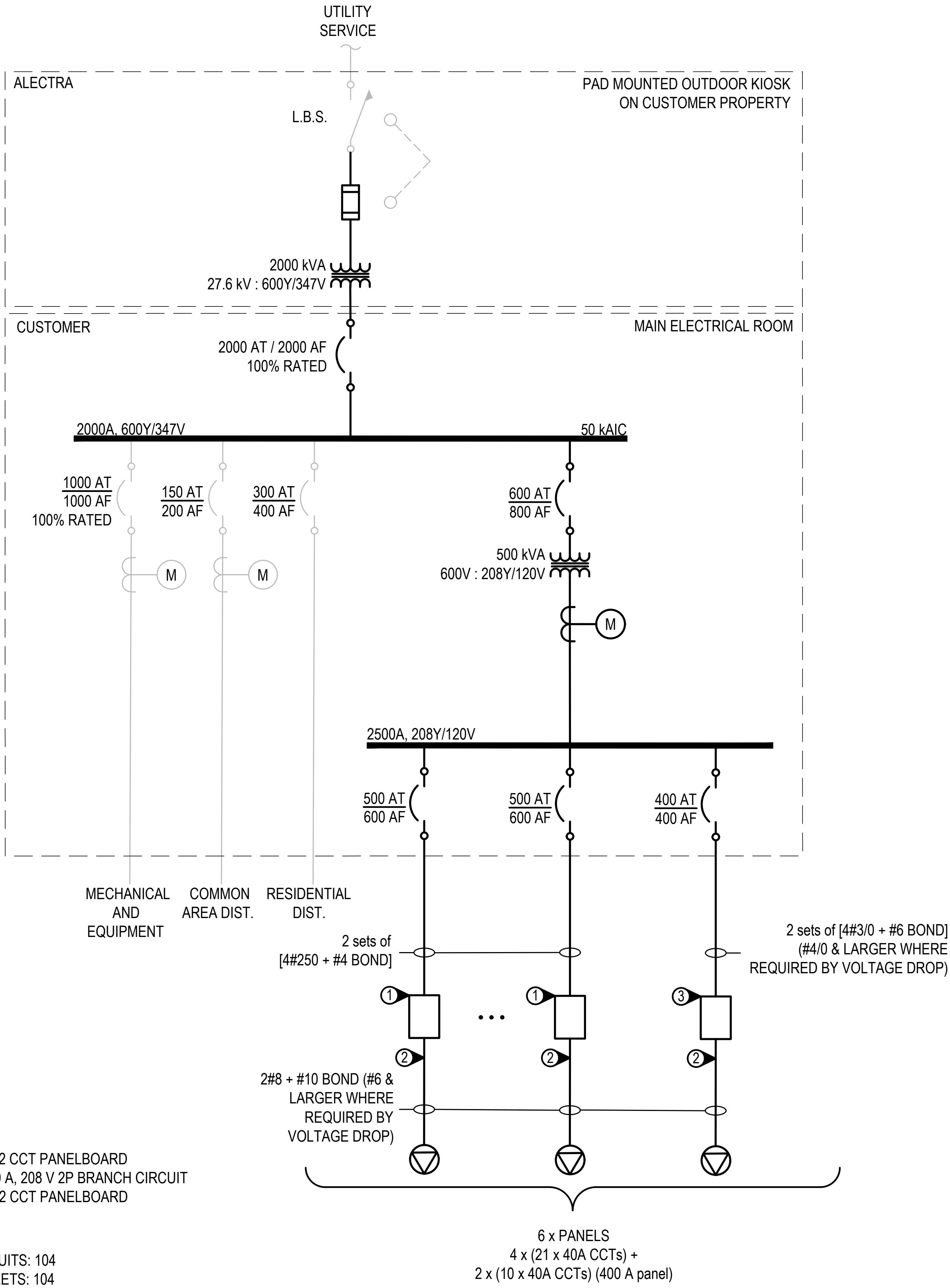
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

MID RISE
C2. 3-SHARE ON 40A, TGS.v3

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-22	3



KEYNOTES:
1. 600 A, 208Y/120V 42 CCT PANELBOARD
2. 1 EV STALL PER 40 A, 208 V 2P BRANCH CIRCUIT
3. 400 A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 104
B) TOTAL EVSE OUTLETS: 104

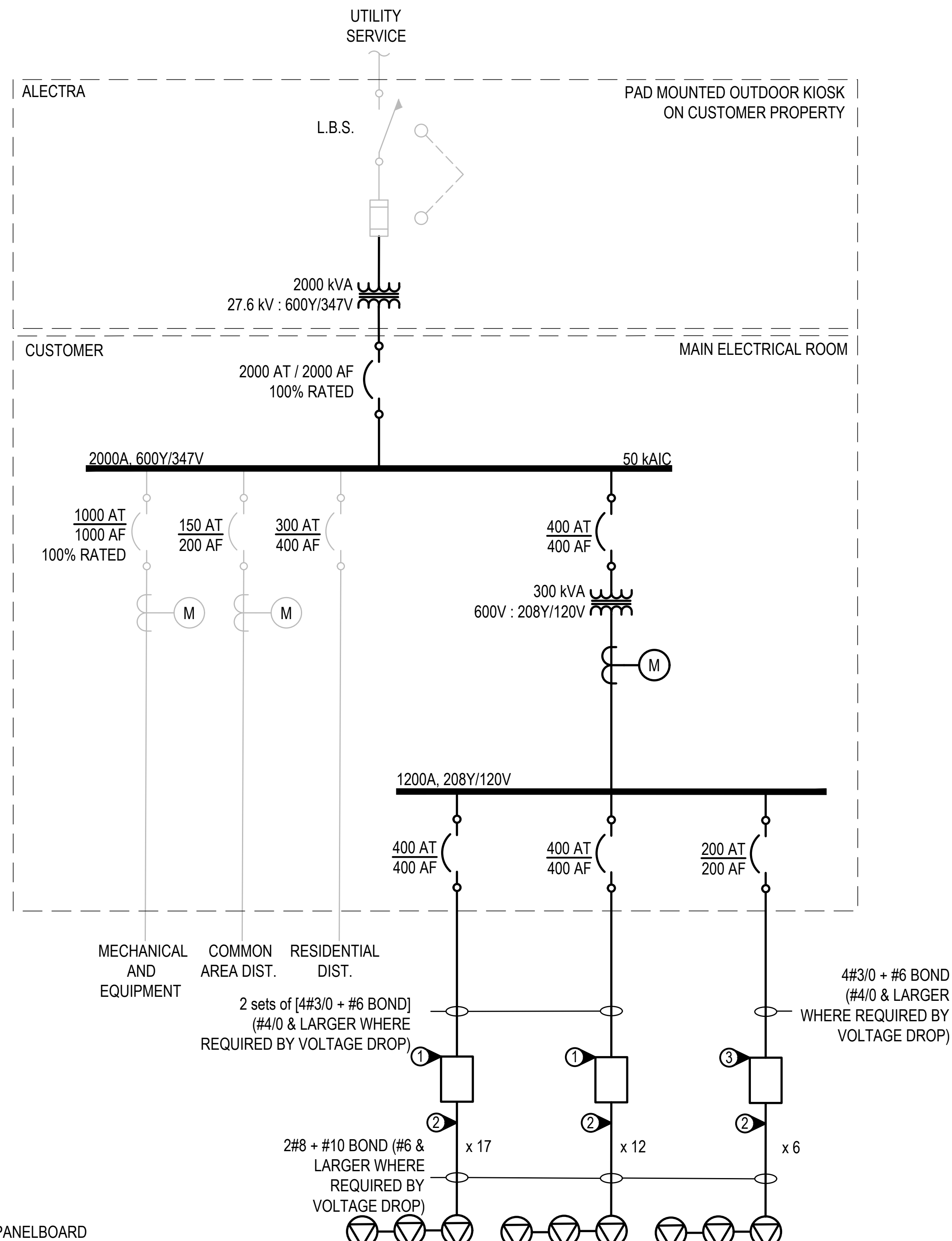
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title
MID RISE
C3. DEDICATED CIRCUITS ON 40A, 100% EV READY

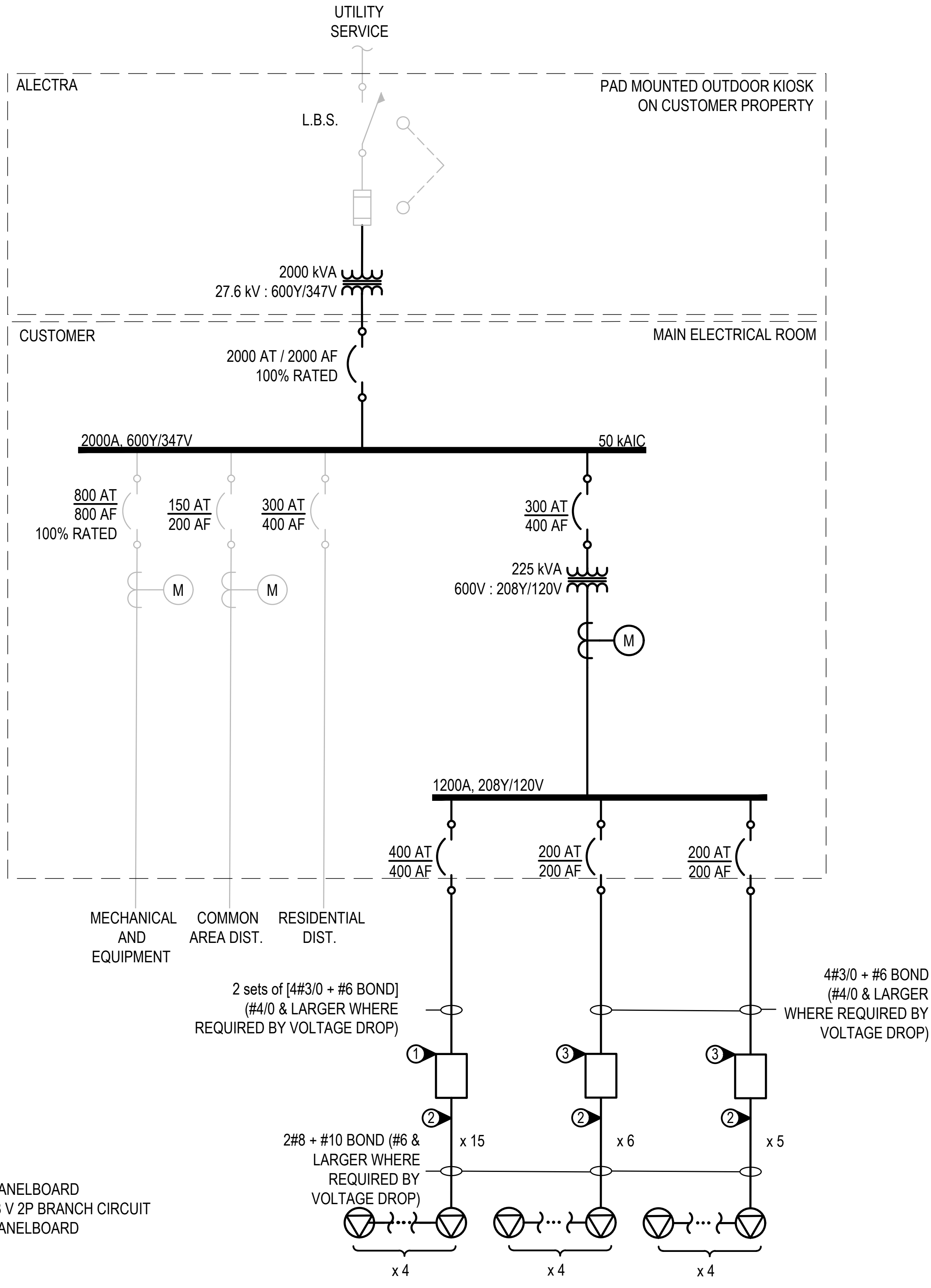
designed	scale	date	
TE	AS NOTED		
drawn	project no.		
TE	2-21-050		
checked	drawing no.		rev.
approved	E-23		3



KEYNOTES:
1. 400 A, 208Y/120V 42 CCT PANELBOARD
2. 3 EV STALLS PER 40 A, 208 V 2P BRANCH CIRCUIT
3. 225 A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 35
B) TOTAL EVSE OUTLETS: 104

consultant	project	designed	scale	date
AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn: TE	project no.: 2-21-050	
	drawing title: MID RISE C4. 3-SHARE ON 40A, 100% EV READY	checked	drawing no.: E-24	rev.: 3
		approved		



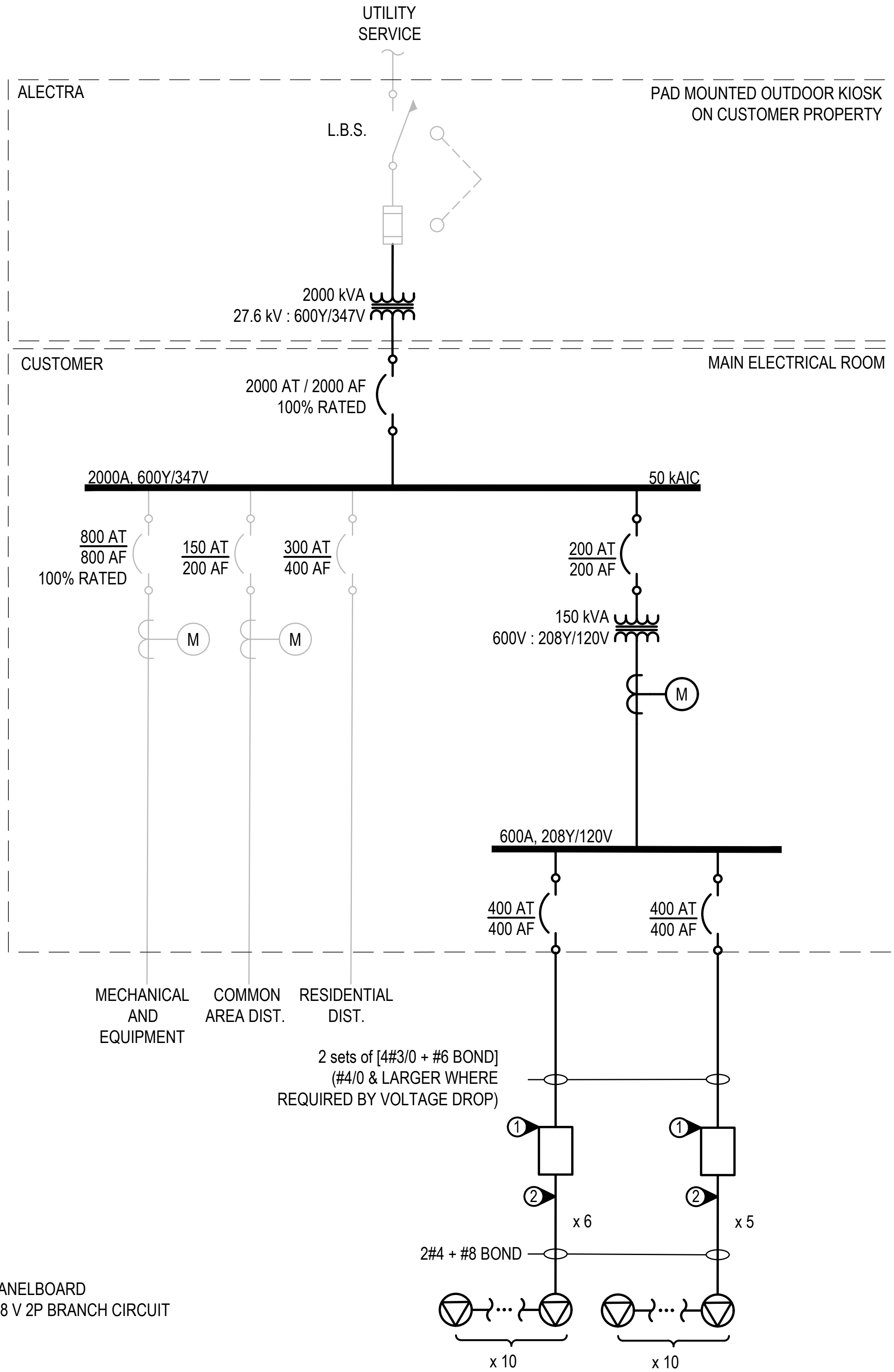
KEYNOTES:

1. 400 A, 208Y/120V 42 CCT PANELBOARD
2. 4 EV STALLS PER 40 A, 208 V 2P BRANCH CIRCUIT
3. 225 A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 26
B) TOTAL EVSE OUTLETS: 104

consultant	project	designed	scale	date
AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn: TE	project no.: 2-21-050	
	drawing title: MID RISE C5. 4-SHARE ON 40A, 100% EV READY	checked	drawing no.: E-25	rev.: 3
		approved		



KEYNOTES:
1. 400 A, 208Y/120V 42 CCT PANELBOARD
2. 10 EV STALLS PER 80 A, 208 V 2P BRANCH CIRCUIT

GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 11
B) TOTAL EVSE OUTLETS: 104

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

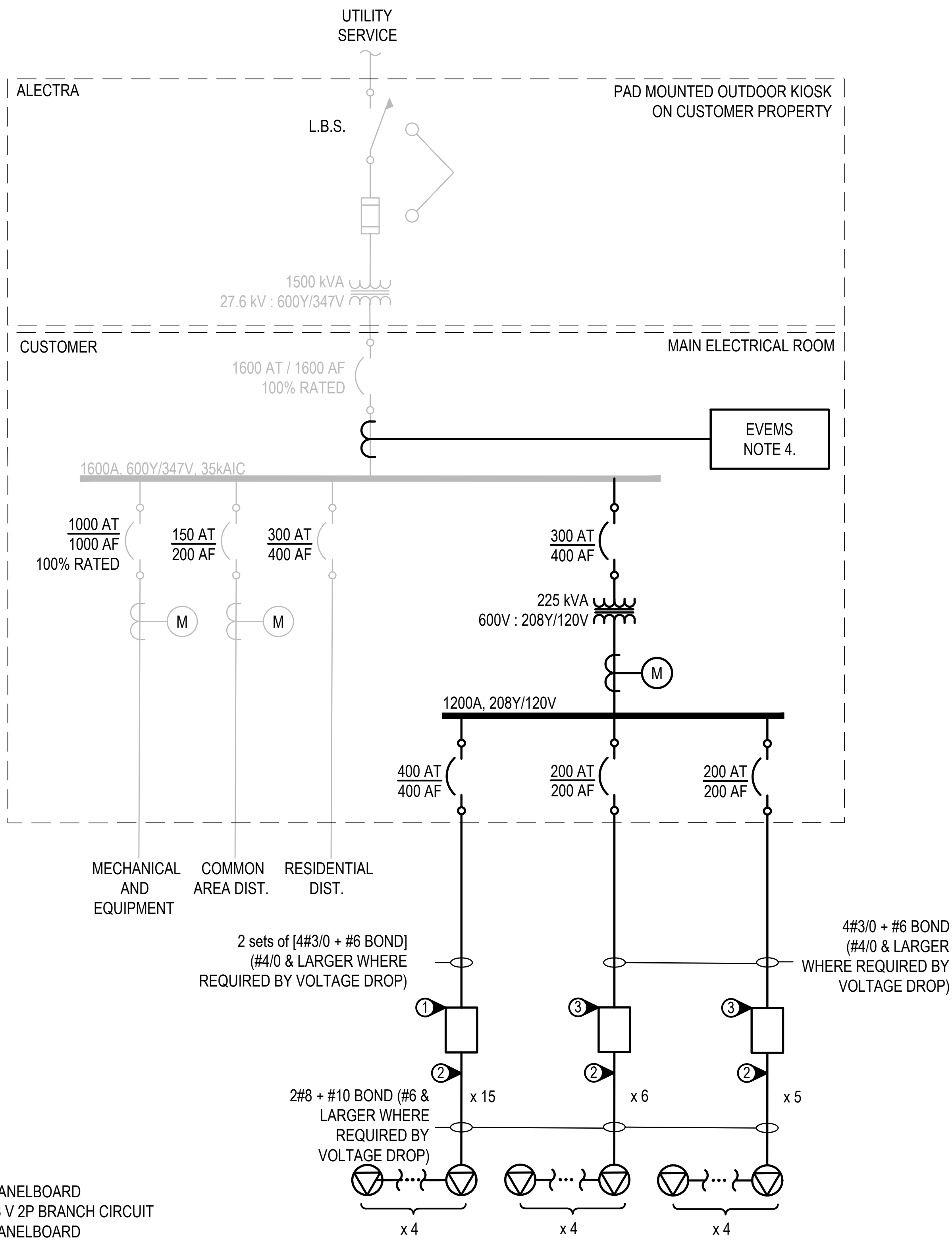
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

MID RISE
C6. 10-SHARE ON 80A, 100% EV READY

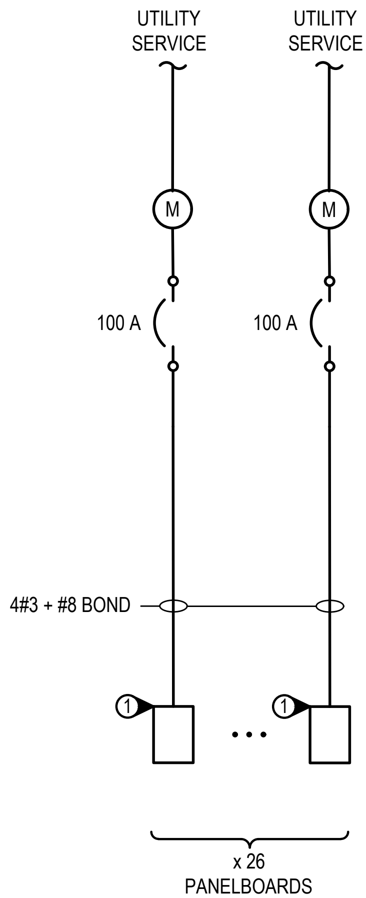
designed TE	scale AS NOTED	date	
drawn TE	project no. 2-21-050		
checked	drawing no. E-26		rev. 3
approved			



KEYNOTES:
1. 400 A, 208Y/120V 42 CCT PANELBOARD
2. 4 EV STALLS PER 40 A, 208 V 2P BRANCH CIRCUIT
3. 225 A, 208Y/120V 42 CCT PANELBOARD
4. EVEMS PROVIDES CONTROL IN ACCORDANCE WITH CEC RULE 8-106 10).

GENERAL NOTES:
A) TOTAL EVSE CIRCUITS: 26
B) TOTAL EVSE OUTLETS: 104

consultant	project	designed	scale	date
AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | **VANCOUVER** | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn: TE	project no.: 2-21-050	
	drawing title: MID RISE C7. 4-SHARE ON 40A, 100% EV READY W/ SERVICE MONITORING	checked	drawing no.: E-27	rev.: 3
		approved		



KEYNOTES:

1. 100A, 208Y/120V 42 CCT PANELBOARD

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

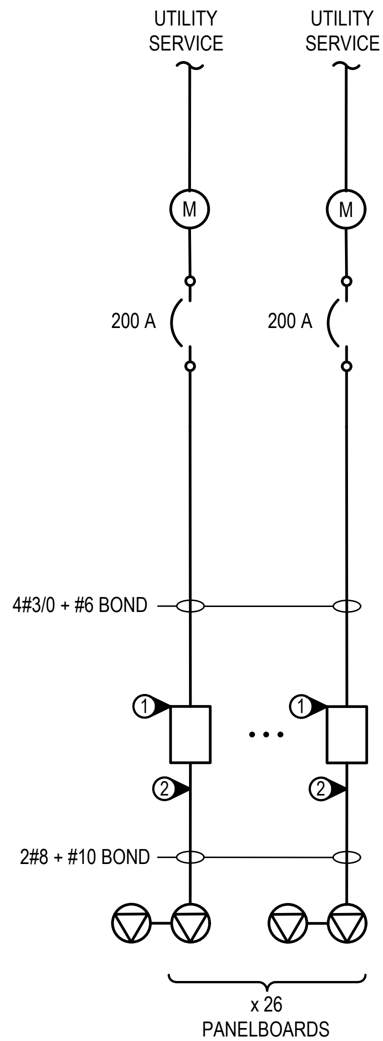
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TOWNHOUSE
BASELINE

designed TE	scale AS NOTED	date
drawn TE	project no. 2-21-050	
checked	drawing no. E-30	rev. 3
approved		



KEYNOTES:

1. 225A, 208Y/120V 42 CCT PANELBOARD
2. 2 EV STALLS PER 40 A, 208 V BRANCH CIRCUIT

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

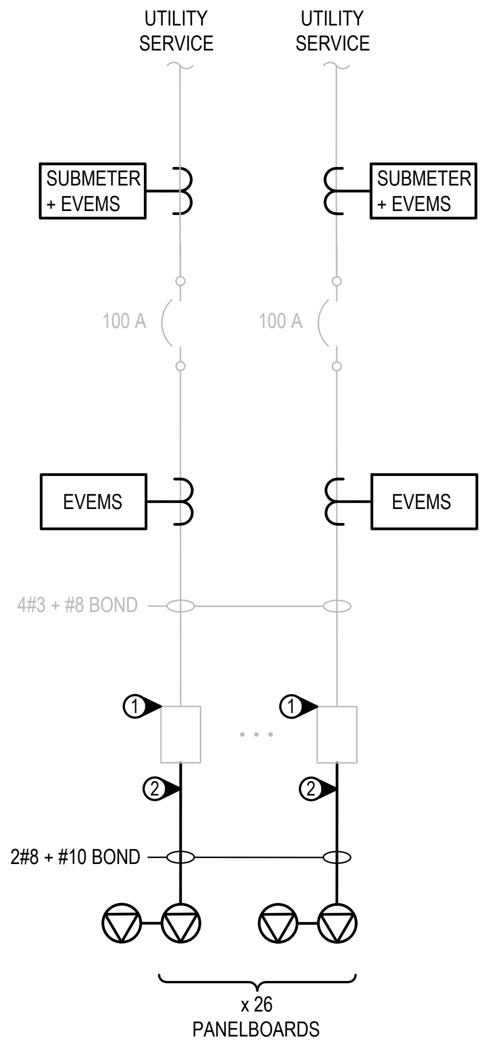
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TOWNHOUSE
C1. 2-SHARE ON 40A, 100% EV READY

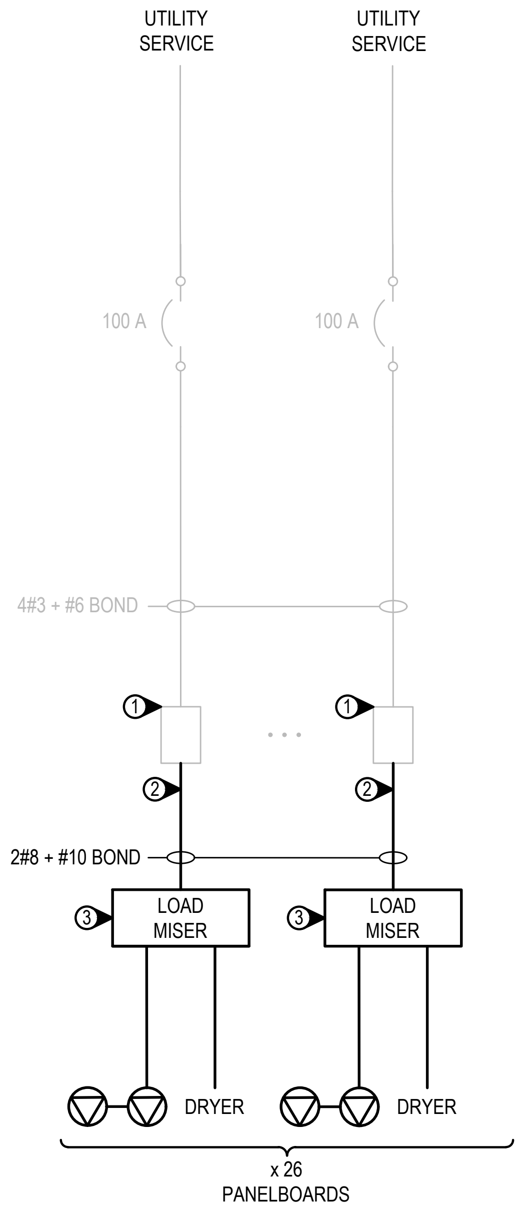
designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-31	3



KEYNOTES:

1. 100A, 208Y/120V 42 CCT PANELBOARD
2. 2 EV STALLS PER 40 A, 208 V BRANCH CIRCUIT

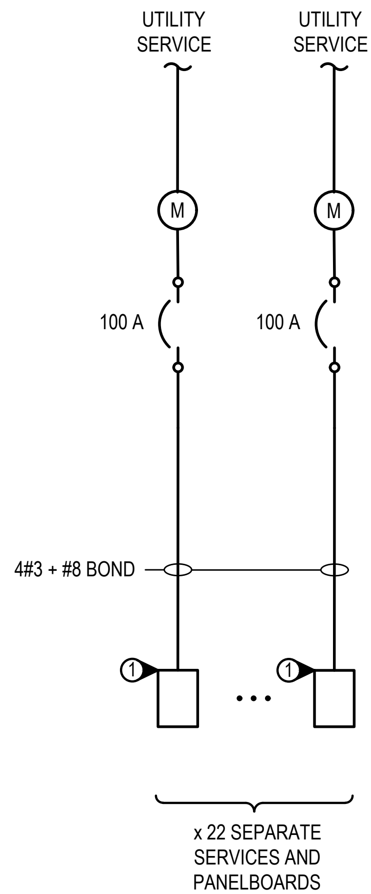
consultant	project	designed	scale	date
AES Designing A Better Tomorrow. 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4. 604.569.6500 | www.aesengr.com. CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn	project no.	
		TE	2-21-050	
	drawing title	checked	drawing no.	rev.
	TOWNHOUSE C2. SERVICE MONITORING	approved	E-32	3



KEYNOTES:

1. 100A, 208Y/120V 42 CCT PANELBOARD
2. 2 EV STALLS PER 40 A, 208 V BRANCH CIRCUIT
3. 40A LOAD MISER.

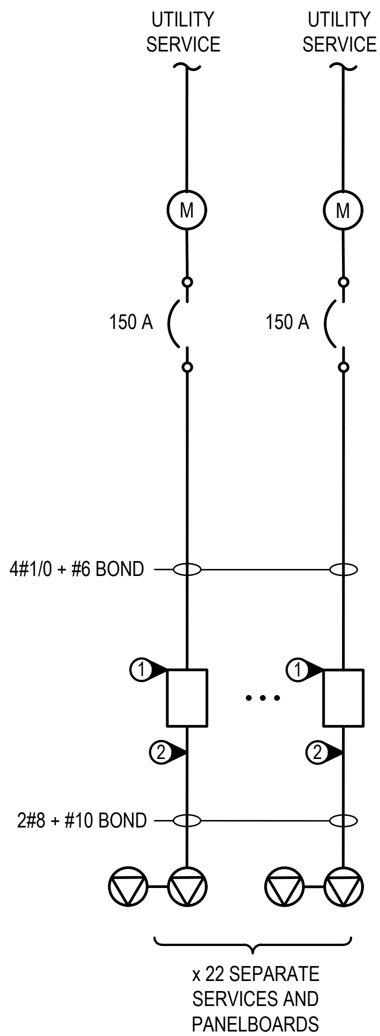
consultant	project	designed	scale	date
AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn TE	project no. 2-21-050	
	drawing title TOWNHOUSE C3. LOAD MISER	checked	drawing no. E-33	rev. 3
		approved		



KEYNOTES:

1. 225A, 120/240V 42 CCT PANELBOARD

consultant	project	designed	scale	date
AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn	project no.	
		TE	2-21-050	
	drawing title	checked	drawing no.	rev.
	SINGLE FAMILY HOME BASELINE	approved	E-40	3



KEYNOTES:

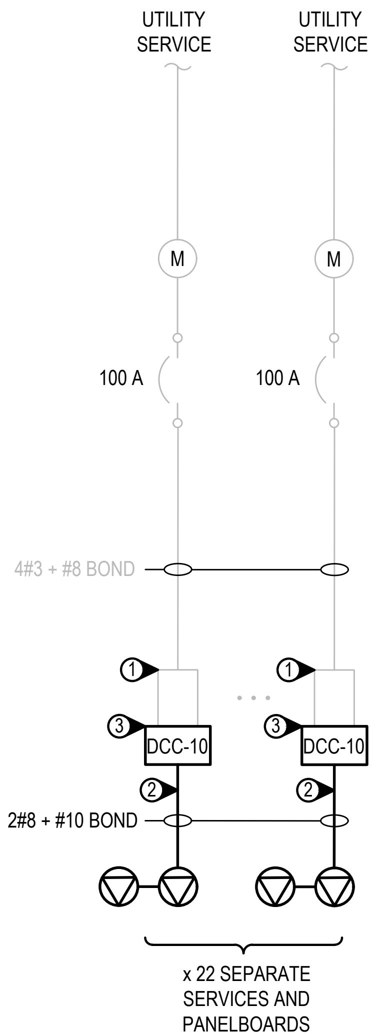
1. 225A, 120/240V 42 CCT PANELBOARD
2. 2 EV STALLS PER 40 A, 208 V BRANCH CIRCUIT

consultant
AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title
SINGLE FAMILY HOME
C1. 2-SHARE ON 40A, 100% EV READY

designed TE	scale AS NOTED	date
drawn TE	project no. 2-21-050	
checked	drawing no. E-41	rev. 3
approved		

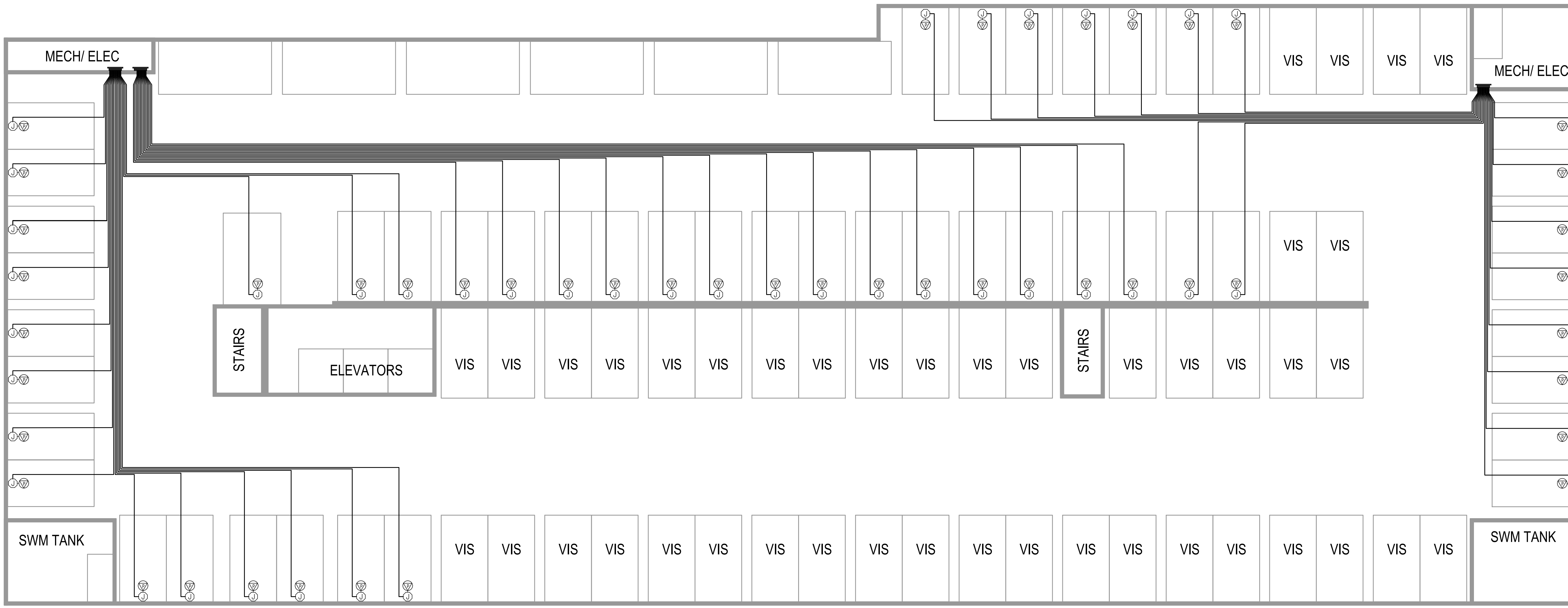


KEYNOTES:

1. 225A, 120/240V 42 CCT PANELBOARD
2. 2 EV STALLS PER 40 A, 208 V BRANCH CIRCUIT
3. DCC-10 ENERGY MANAGEMENT SYSTEM OR SIMILAR LOAD-SWITCHING UNIT.

consultant	project	designed	scale	date
AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn TE	project no. 2-21-050	
	drawing title: SINGLE FAMILY HOME C2. LOAD SWITCHING	checked	drawing no. E-42	rev. 3
		approved		

Appendix C: Parking layout drawings



seal	consultant AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	project CLEAN AIR PARTNERSHIP EV COSTING STUDY	
		drawing title HIGH RISE P1 C1. DEDICATED CIRCUITS ON 40A, TGS	

designed TK	scale AS NOTED	date FEBRUARY, 2021	
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-100-P1		rev. 01
approved VL			

seal

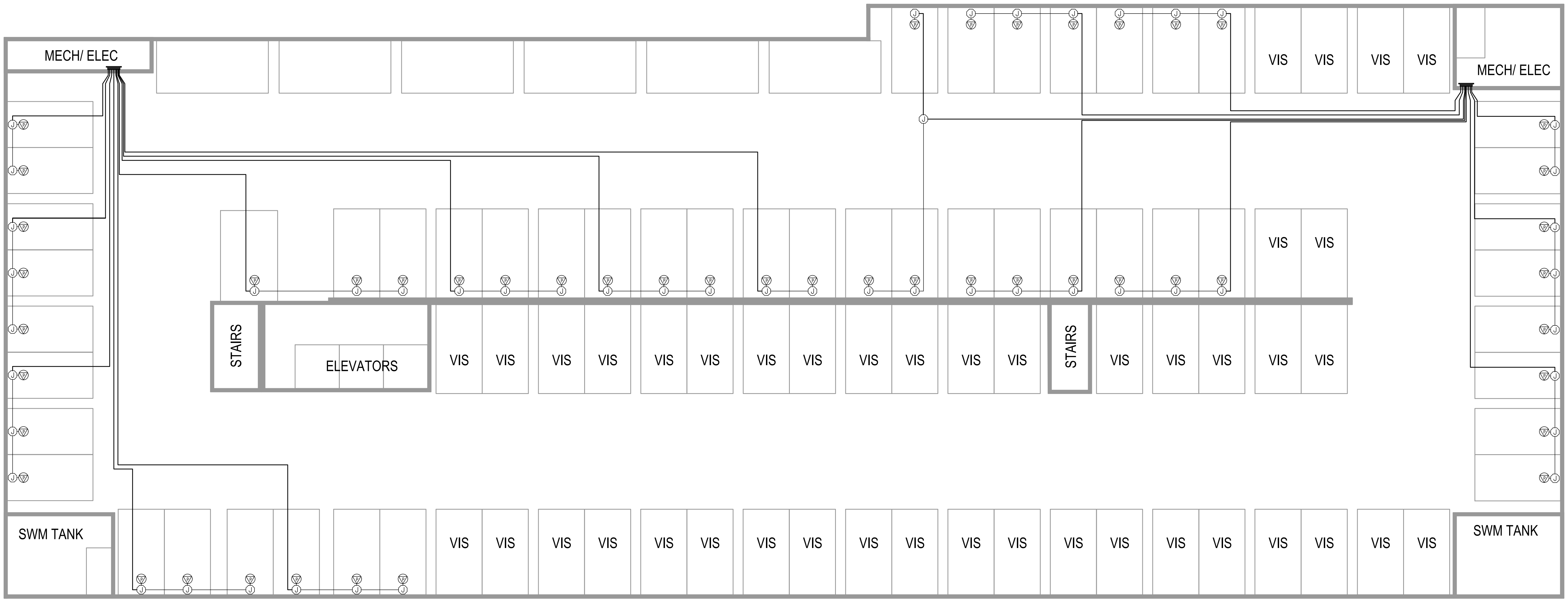
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title
HIGH RISE P2
C1. DEDICATED CIRCUITS ON 40A, TGS

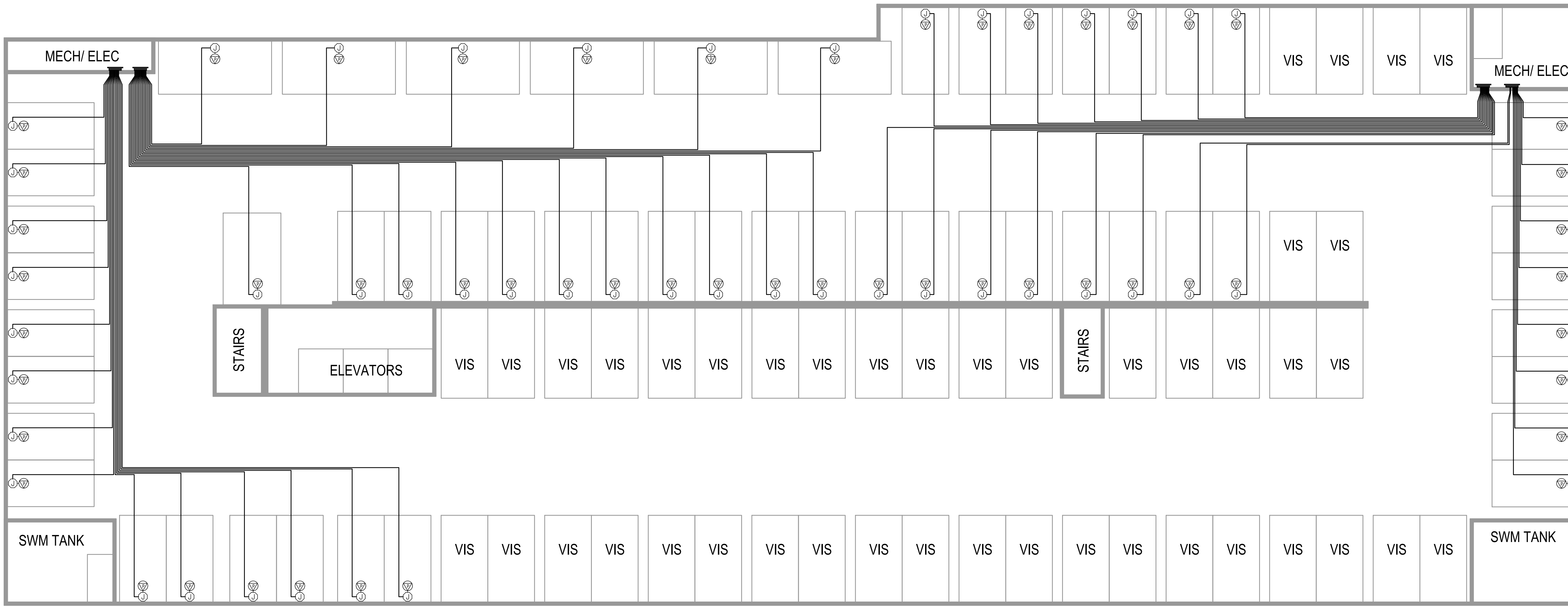
designed TK	scale AS NOTED		date FEBRUARY, 2021
drawn TK	project no. 2-21-050		
checked VL	drawing no.		rev.
approved VL	E-100-P2		01



seal	consultant	project	designed	scale	date
	AES Designing A Better Tomorrow	CLEAN AIR PARTNERSHIP EV COSTING STUDY	TK	AS NOTED	FEBRUARY, 2021
			drawn TK	project no. 2-21-050	
		drawing title HIGH RISE P1 C2. 3-SHARE ON 40A, TGS	checked VL	drawing no. E-101-P1	rev. 01
			approved VL		

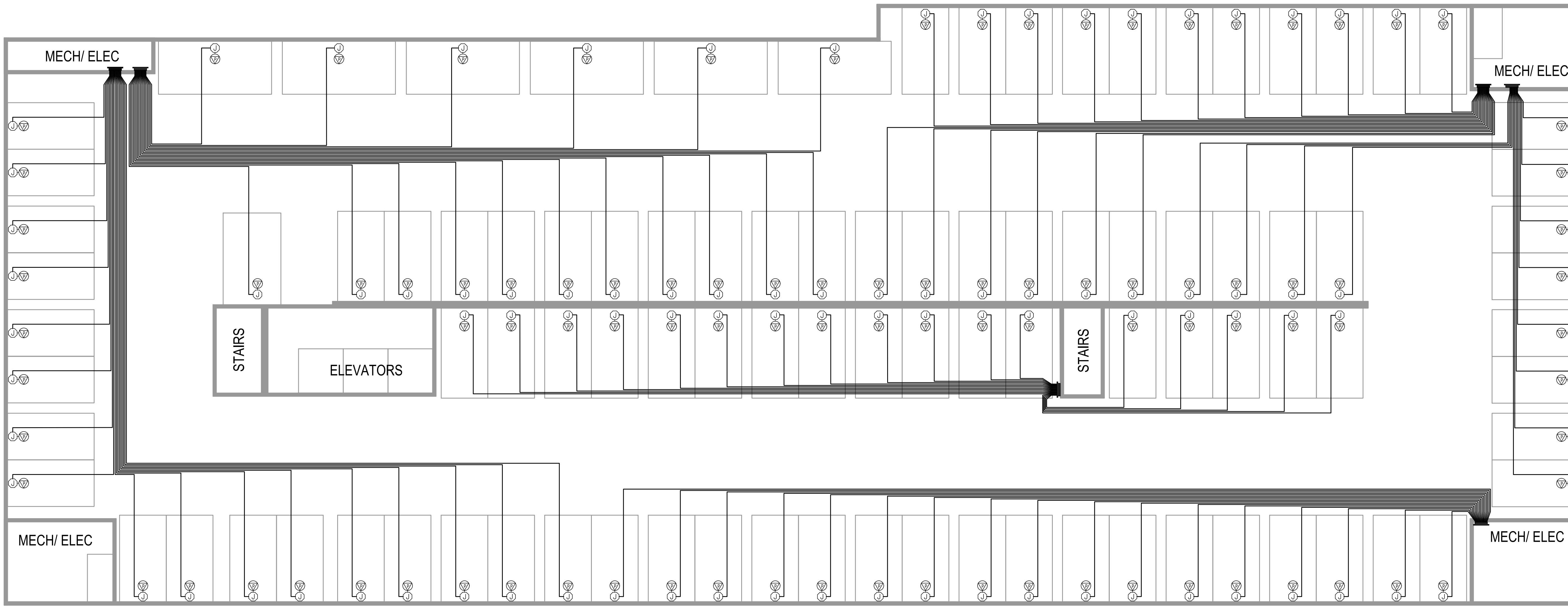
seal	consultant	project	
	AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV COSTING STUDY	
		drawing title: HIGH RISE P2 C2. 3-SHARE ON 40A, TGS	

designed	TK	scale	AS NOTED	date	FEBRUARY, 2021
drawn	TK	project no.	2-21-050		
checked	VL	drawing no.	E-101-P2	rev.	01
approved	VL				



seal	consultant AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	project CLEAN AIR PARTNERSHIP EV COSTING STUDY drawing title HIGH RISE P1 C3. DEDICATED ON 40A, 100% EV READY	

designed TK	scale AS NOTED	date FEBRUARY, 2021	
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-102-P1		rev. 01
approved VL			



seal

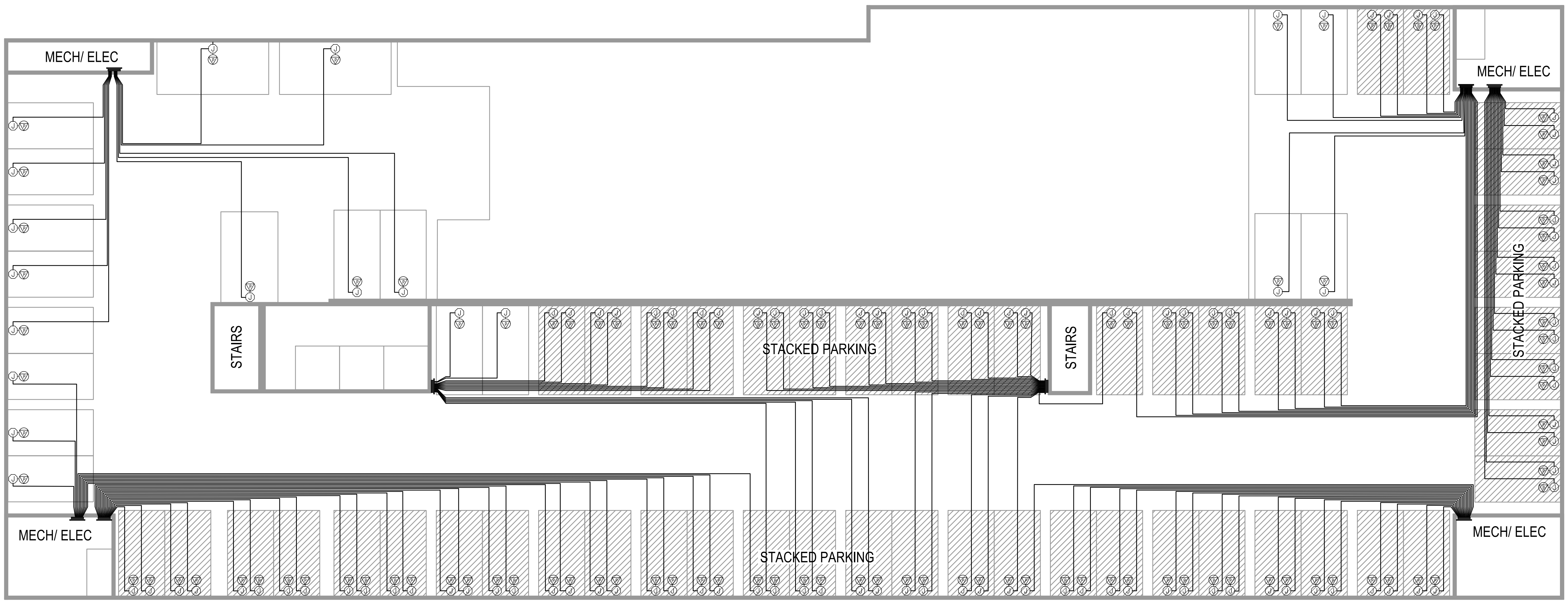
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

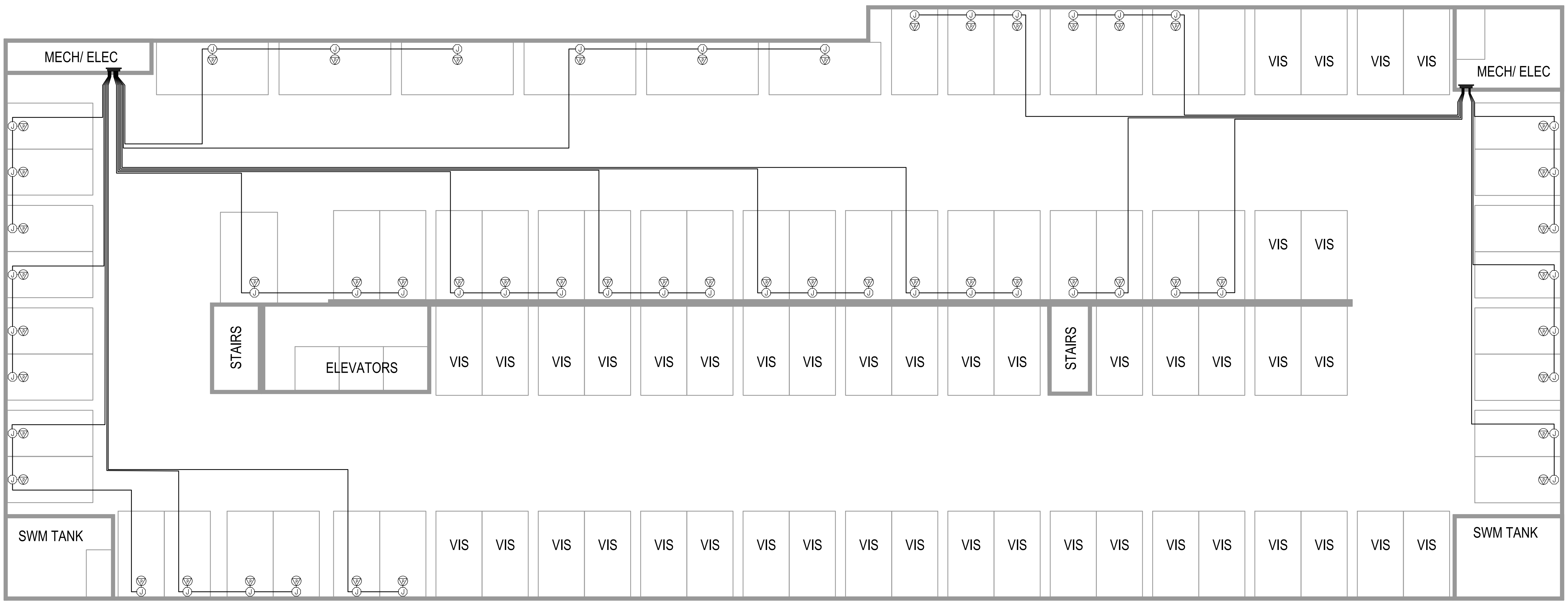
project
CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title
HIGH RISE P2-P3
C3. DEDICATED ON 40A, 100% EV READY

designed	TK	scale	AS NOTED	date	FEBRUARY, 2021
drawn	TK	project no.	2-21-050		
checked	VL	drawing no.	E-102-P2-P3	rev.	01
approved	VL				

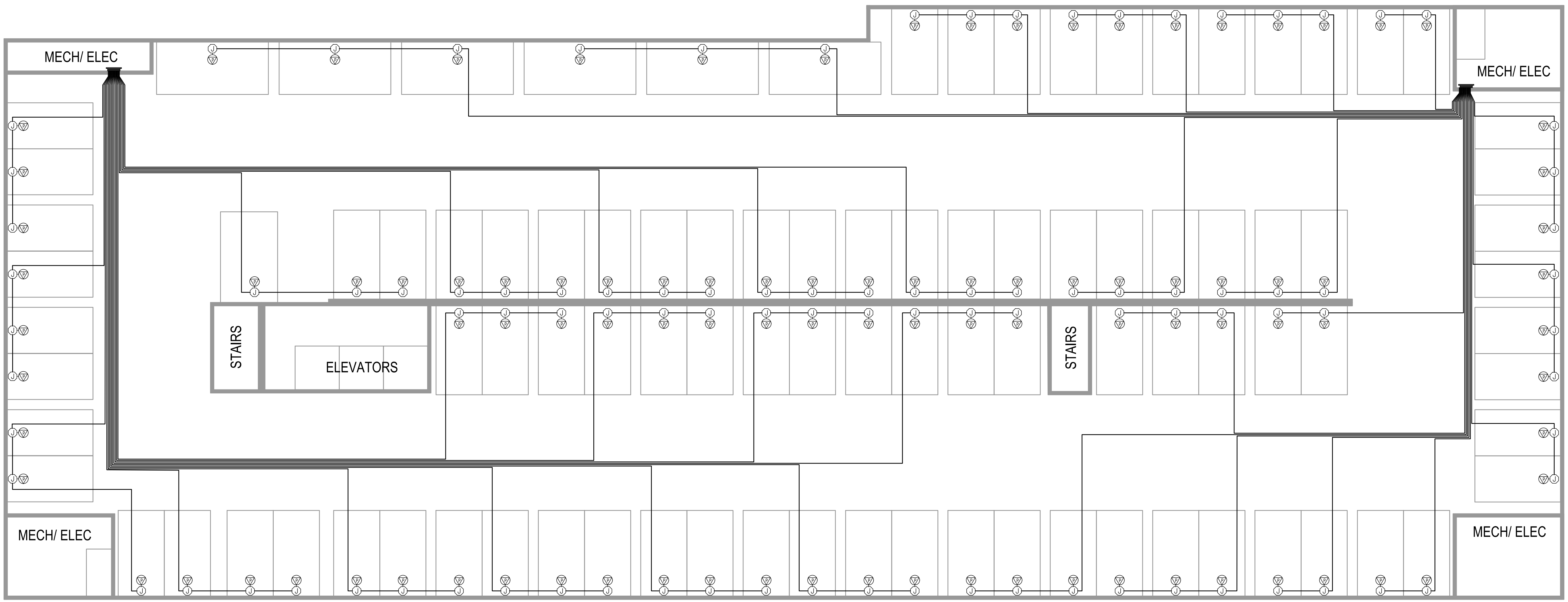


seal	consultant	project			
	AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | **VANCOUVER** | VICTORIA	CLEAN AIR PARTNERSHIP EV COSTING STUDY	designed: TK	scale: AS NOTED	date: FEBRUARY, 2021
			drawn: TK	project no.: 2-21-050	
		drawing title: HIGH RISE P4 C3. DEDICATED ON 40A, 100% EV READY	checked: VL	drawing no.: E-102-P4	rev.: 01
			approved: VL		



seal	consultant AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | **VANCOUVER** | VICTORIA	project CLEAN AIR PARTNERSHIP EV COSTING STUDY drawing title HIGH RISE P1 C4. 3-SHARE ON 40A, 100% EV READY

designed: TK	scale: AS NOTED	date: FEBRUARY, 2021	
drawn: TK	project no.: 2-21-050		
checked: VL	drawing no.: E-103-P1		rev.: 01
approved: VL			



seal

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

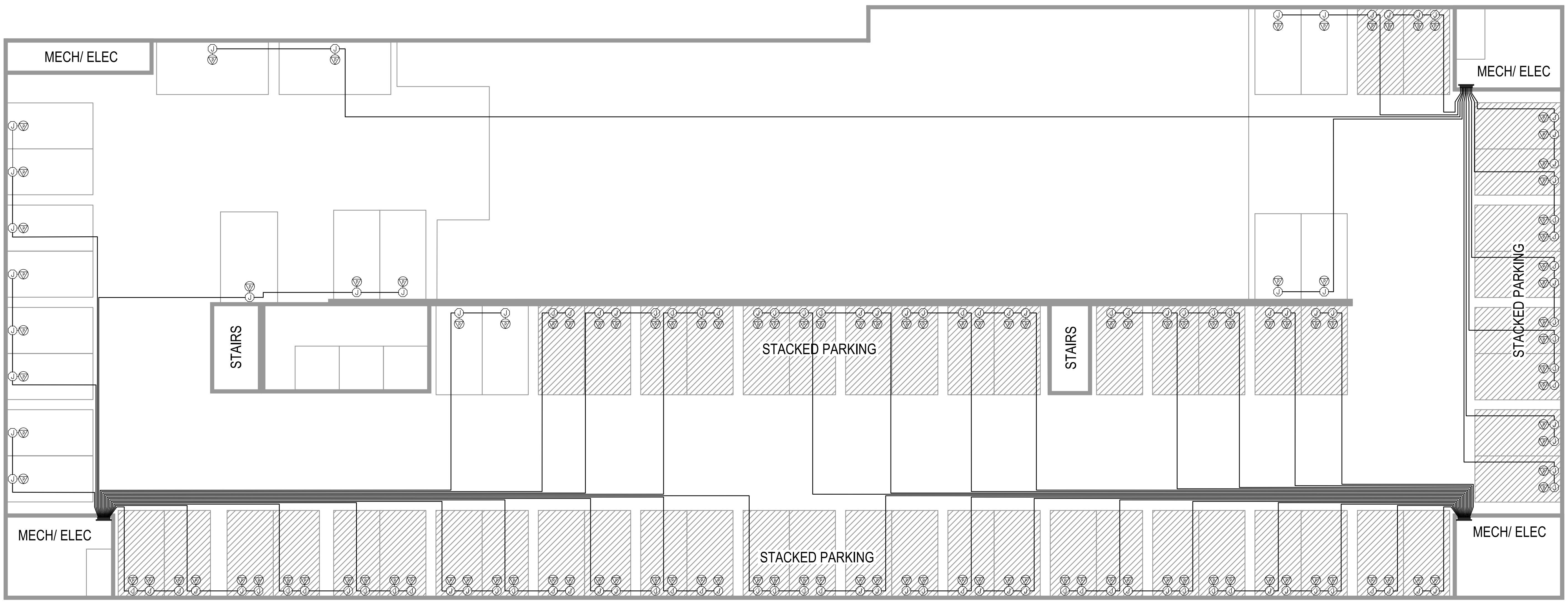
project

CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title

HIGH RISE P2-P3
C4. 3-SHARE ON 40A, 100% EV READY

designed TK	scale AS NOTED	date FEBRUARY, 2021	
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-103-P2-P3		rev. 01
approved VL			



seal

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project

CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title

HIGH RISE P4
C4. 3-SHARE ON 40A, 100% EV READY

designed TK	scale AS NOTED		date FEBRUARY, 2021
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-103-P4		rev. 01
approved VL			

seal

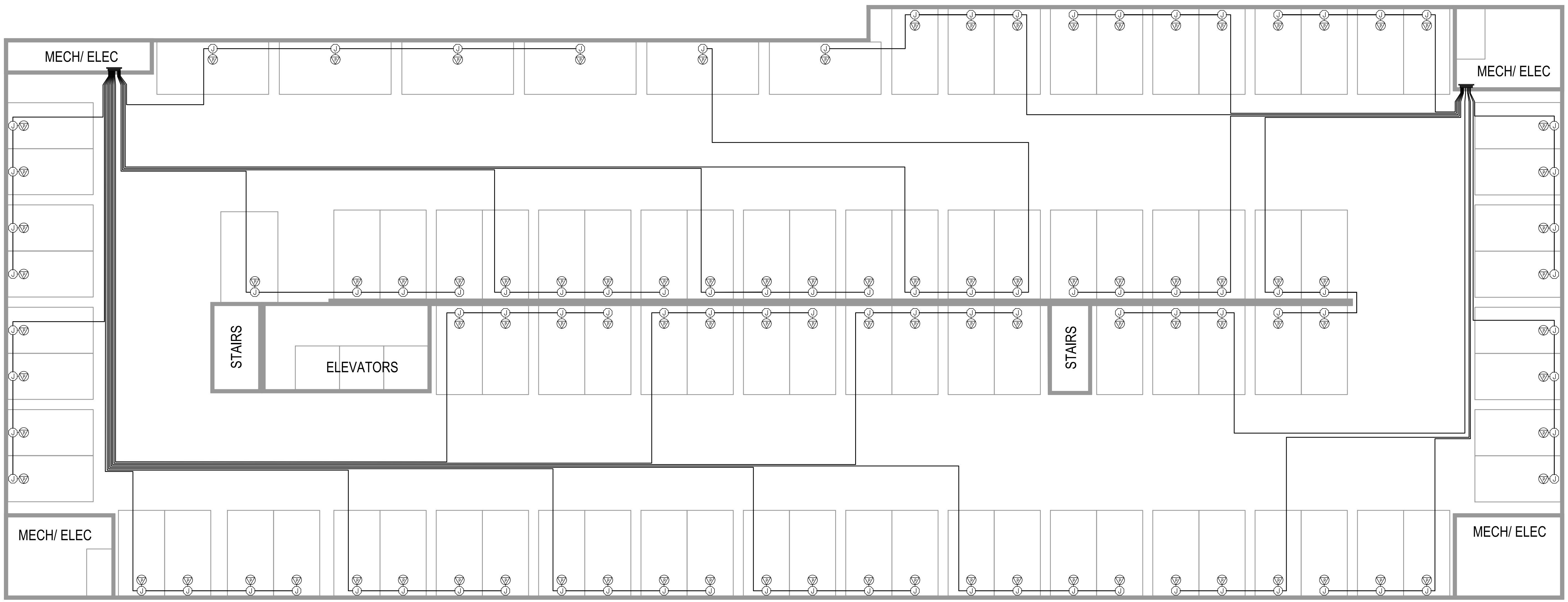
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

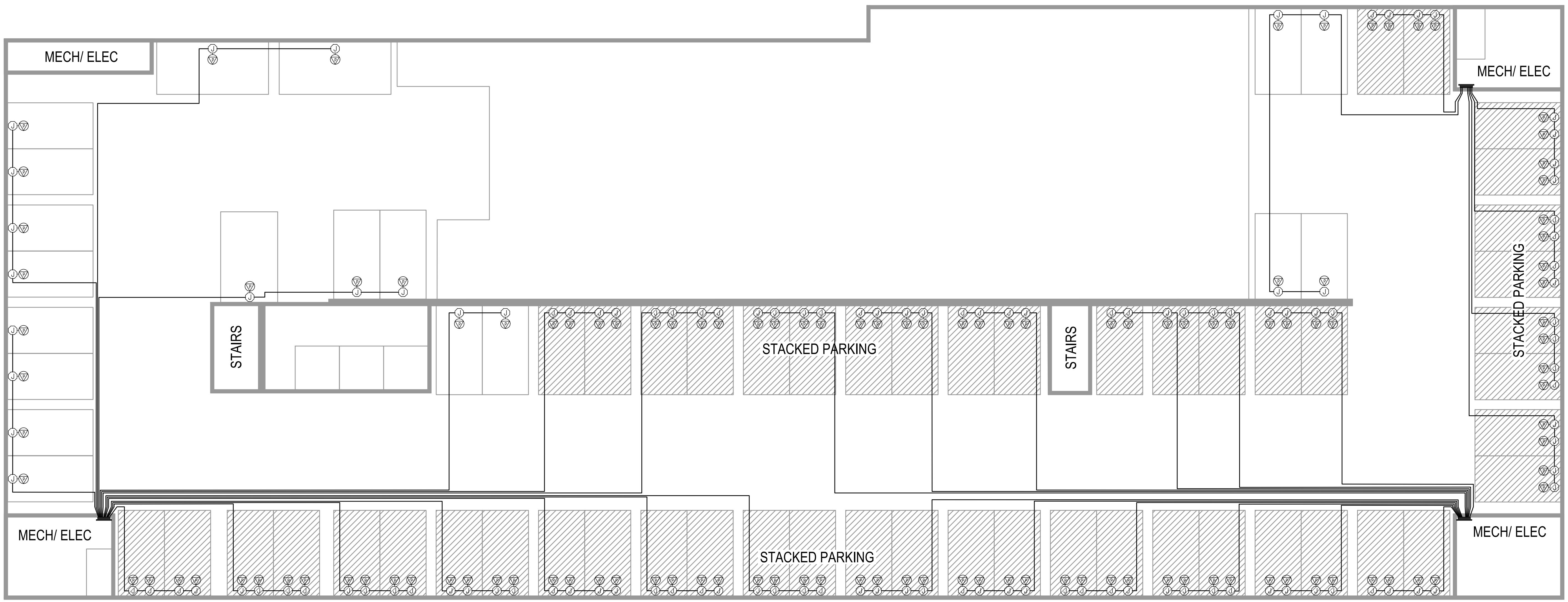
project
CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title
HIGH RISE P1
C5. 4-SHARE ON 40A, 100% EV READY

designed TK	scale AS NOTED	date FEBRUARY, 2021	
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-104-P1		rev. 01
approved VL			



seal		
consultant	AES Designing A Better Tomorrow	
project	CLEAN AIR PARTNERSHIP EV COSTING STUDY	
drawing title	HIGH RISE P2-P3 C5. 4-SHARE ON 40A, 100% EV READY	
designed: TK	scale: AS NOTED	date: FEBRUARY, 2021
drawn: TK	project no.: 2-21-050	
checked: VL	drawing no.: E-104-P2-P3	rev.: 01
approved: VL		



seal

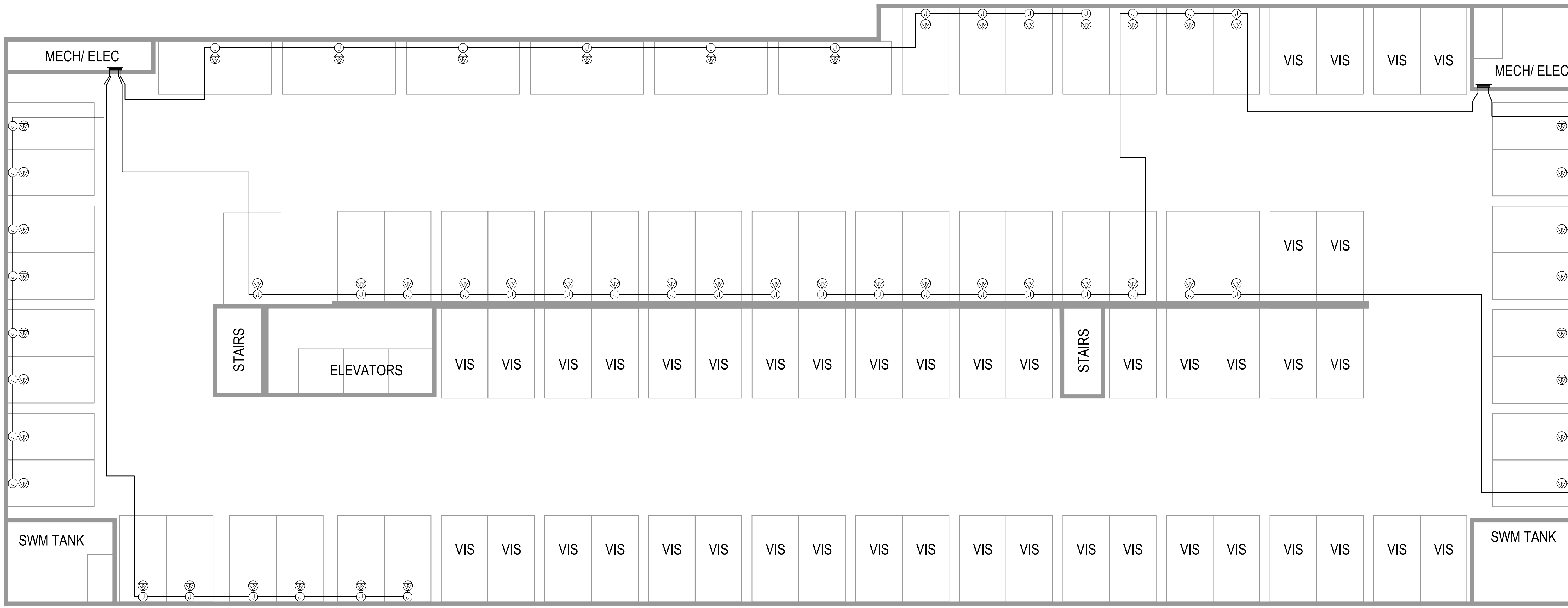
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title
HIGH RISE P4
C5. 4-SHARE ON 40A, 100% EV READY

designed TK	scale AS NOTED	date FEBRUARY, 2021	
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-104-P4		rev. 01
approved VL			



seal	consultant: AES Designing A Better Tomorrow, 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4, 604.569.6500 | www.aesengr.com, CALGARY | VANCOUVER | VICTORIA	project: CLEAN AIR PARTNERSHIP EV COSTING STUDY
		drawing title: HIGH RISE P1 C6. 10-SHARE ON 80A, 100% EV READY

designed: TK	scale: AS NOTED	date: FEBRUARY, 2021	
drawn: TK	project no.: 2-21-050		
checked: VL	drawing no.: E-105-P1		rev.: 01
approved: VL			

seal

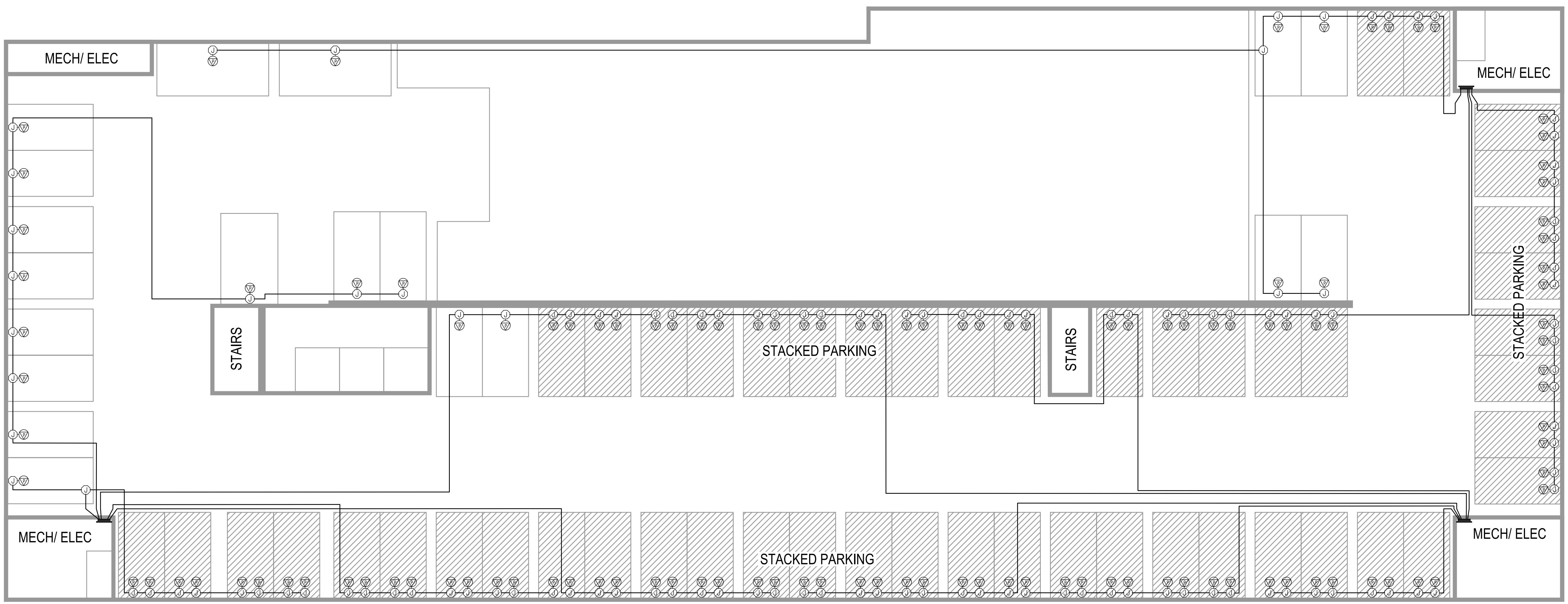
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title
HIGH RISE P2-P3
C6. 10-SHARE ON 80A, 100% EV READY

designed TK	scale AS NOTED		date FEBRUARY, 2021
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-105-P2-P3		rev. 01
approved VL			



seal

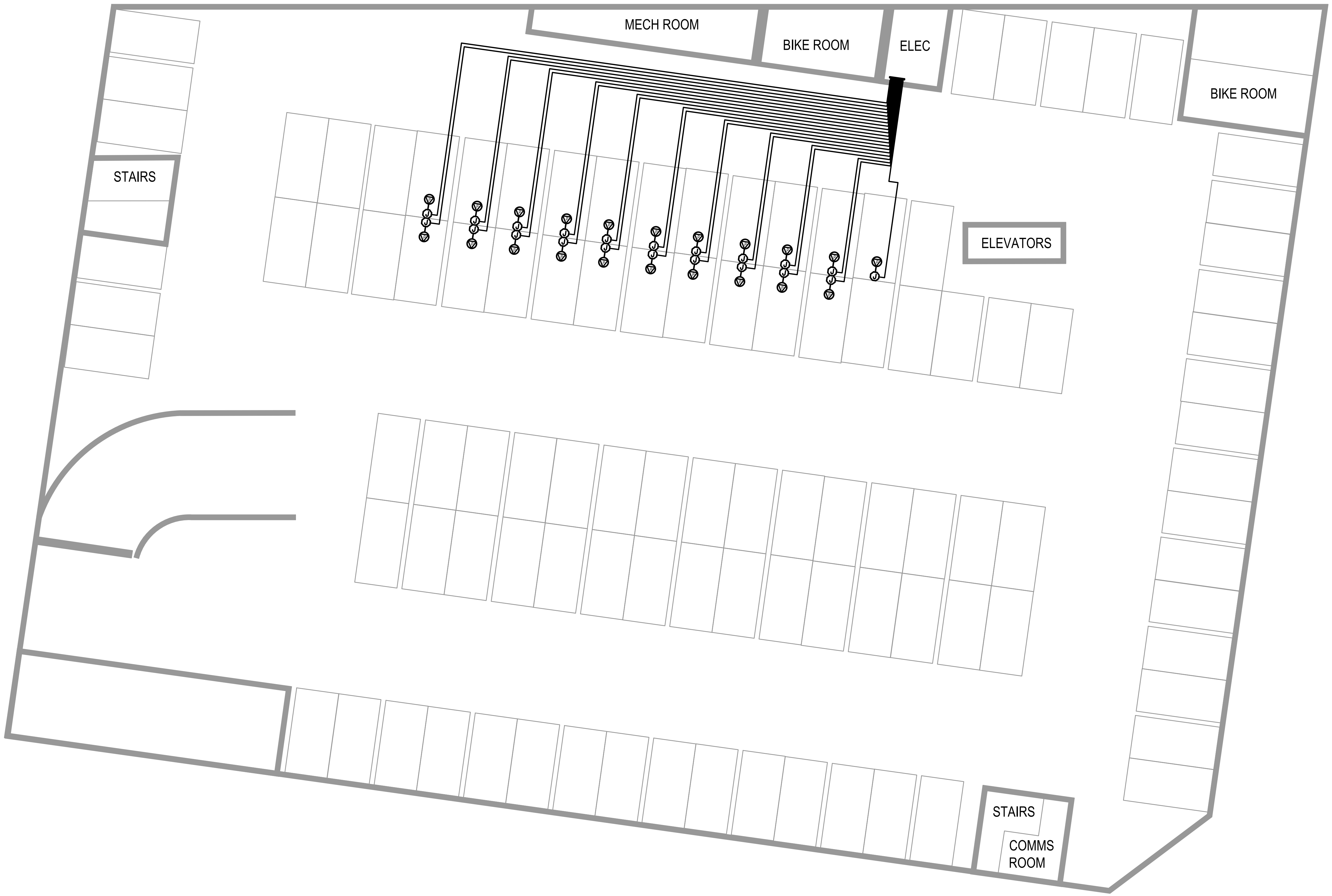
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project
CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title
HIGH RISE P4
C6. 10-SHARE ON 80A, 100% EV READY

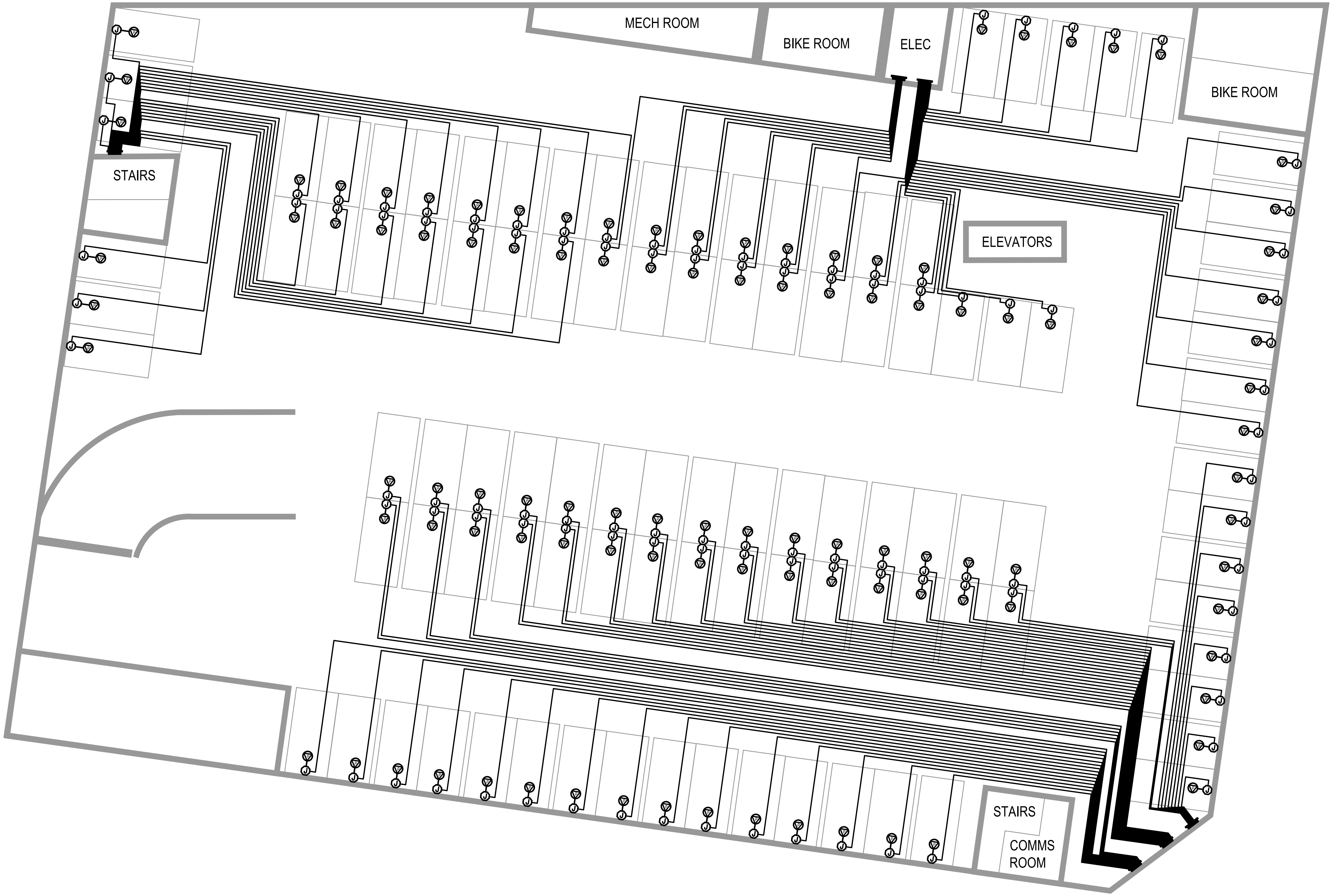
designed TK	scale AS NOTED		date FEBRUARY, 2021
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-105-P4		rev. 01
approved VL			



seal	consultant AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | **VANCOUVER** | VICTORIA	project CLEAN AIR PARTNERSHIP EV COSTING STUDY drawing title MID RISE C1. DEDICATED CIRCUITS ON 40A, TGS	designed TK drawn TK checked VL approved VL	scale AS NOTED date FEBRUARY, 2021 project no. 2-21-050 drawing no. E-200 rev. 01

seal	consultant	project	
	AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | **VANCOUVER** | VICTORIA	CLEAN AIR PARTNERSHIP EV COSTING STUDY	
		drawing title: MID RISE C2. 3-SHARE ON 40A, TGS	

designed	TK	scale	AS NOTED	date	FEBRUARY, 2021
drawn	TK	project no.	2-21-050		
checked	VL	drawing no.	E-201	rev.	01
approved	VL				



seal

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

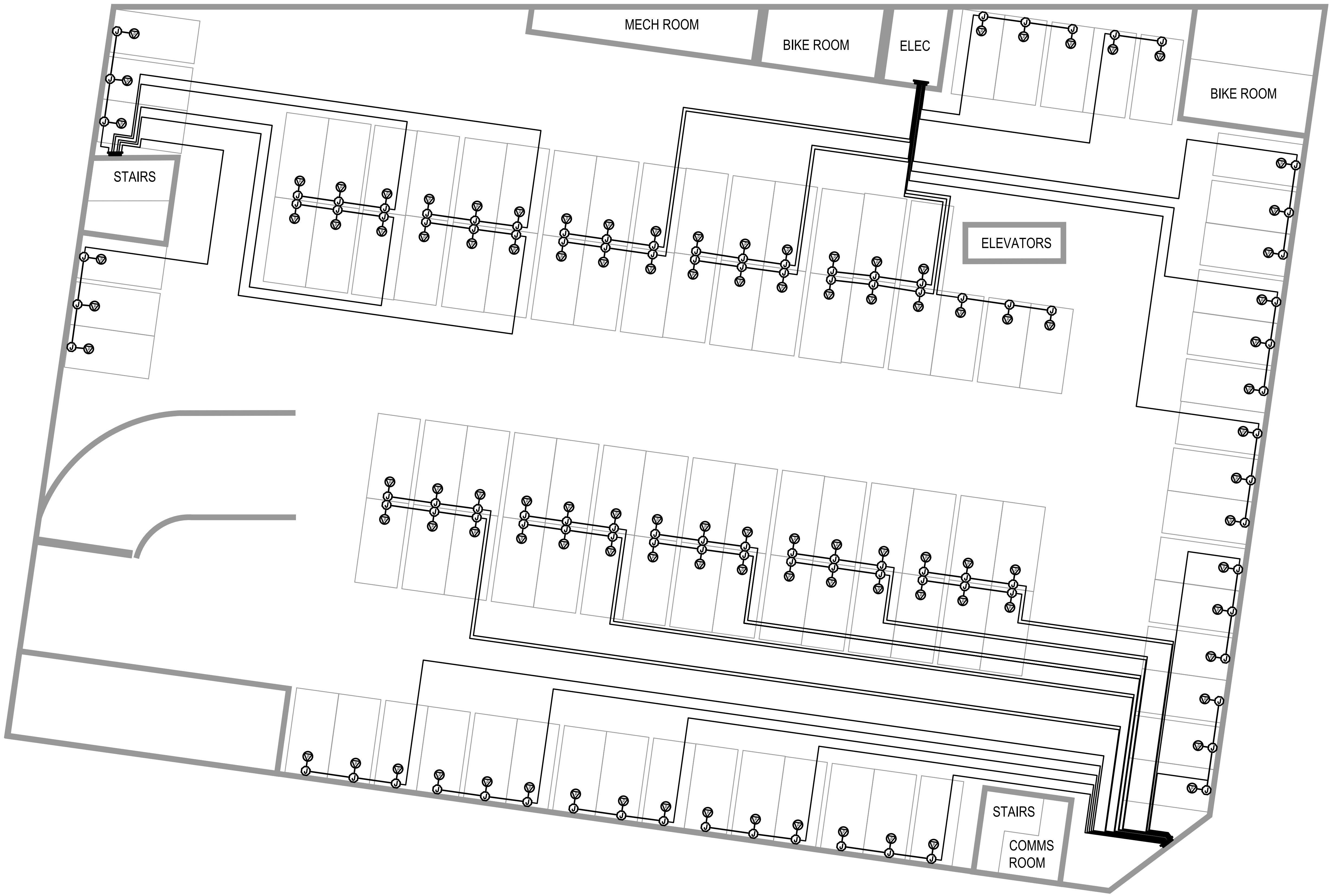
project

CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title

MID RISE
C3. DEDICATED ON 40A, 100% EV READY

designed TK	scale AS NOTED		date FEBRUARY, 2021
drawn TK	project no. 2-21-050		
checked VL	drawing no.	E-202	rev. 01
approved VL			



seal	consultant AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | **VANCOUVER** | VICTORIA	project CLEAN AIR PARTNERSHIP EV COSTING STUDY	
		drawing title MID RISE C4. 3-SHARE ON 40A, 100% EV READY	

designed TK	scale AS NOTED		date FEBRUARY, 2021
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-203		rev. 01
approved VL			

seal

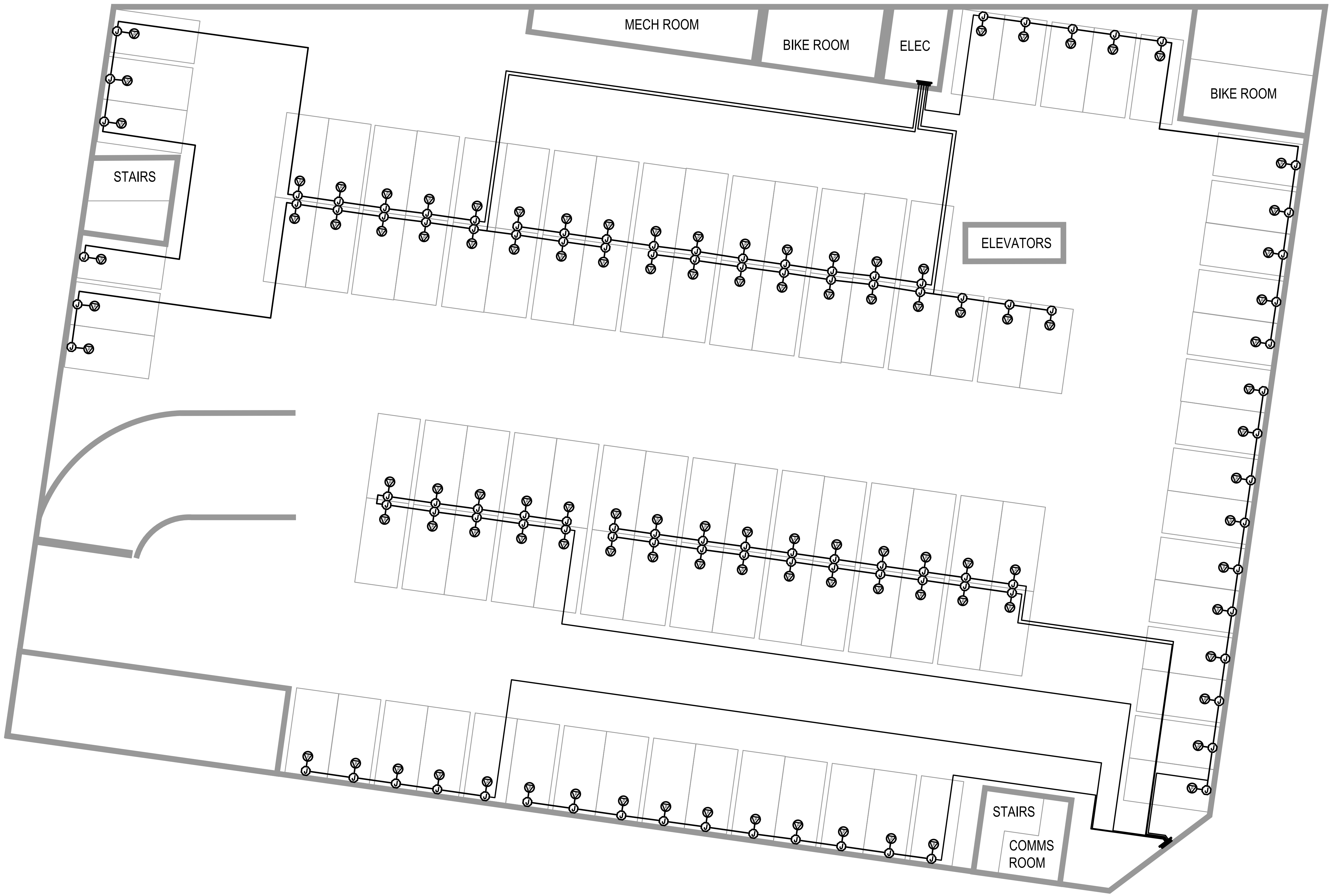
consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

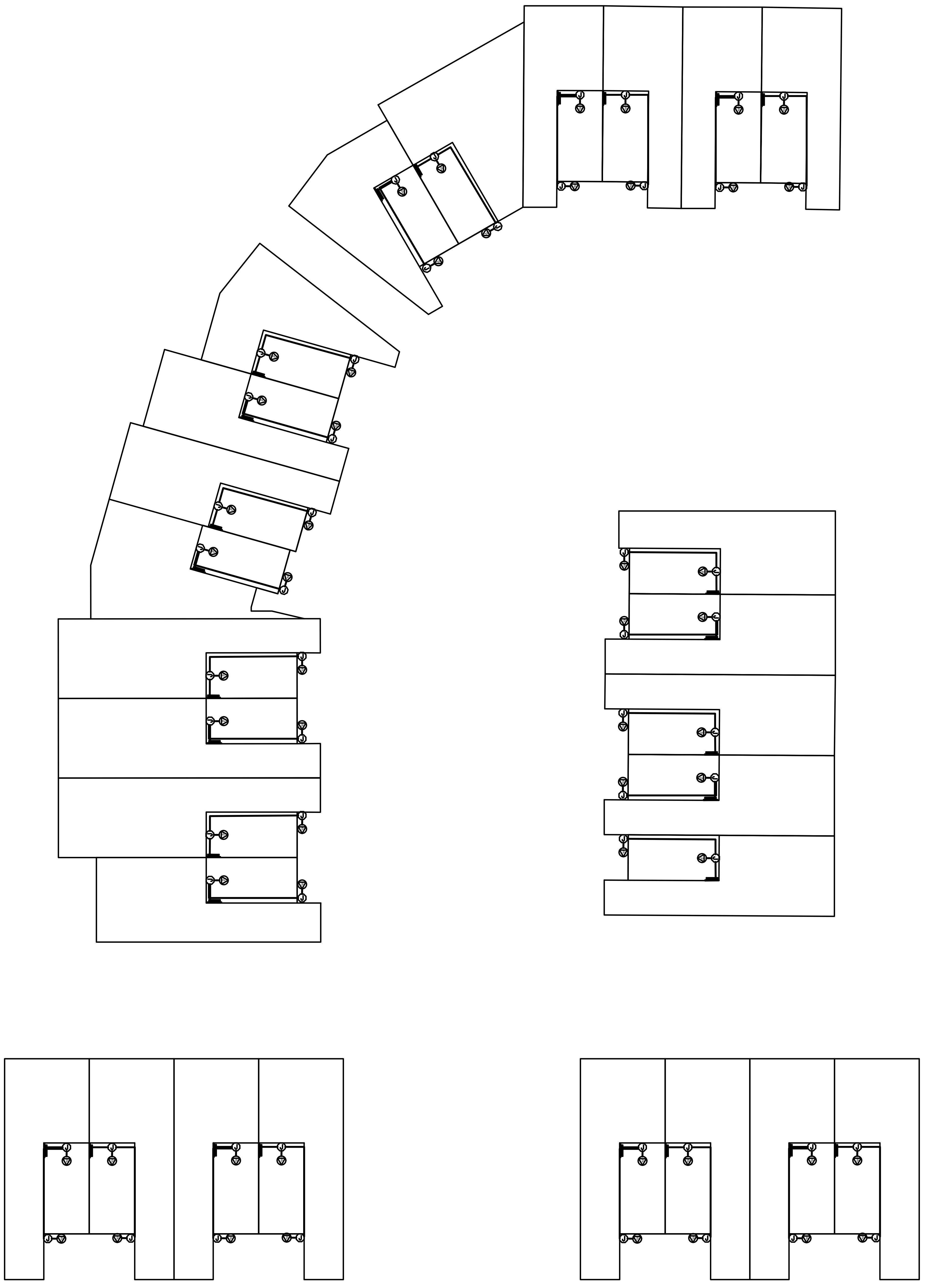
project
CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title
MID RISE
C5. 4-SHARE ON 40A, 100% EV READY

designed TK	scale AS NOTED		date FEBRUARY, 2021
drawn TK	project no. 2-21-050		
checked VL	drawing no. E-204		rev. 01
approved VL			



seal	consultant AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	project CLEAN AIR PARTNERSHIP EV COSTING STUDY drawing title MID RISE C6. 10-SHARE ON 80A, 100% EV READY	designed TK drawn TK checked VL approved VL scale AS NOTED date FEBRUARY, 2021 project no. 2-21-050 drawing no. E-205 rev. 01



seal

consultant

Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

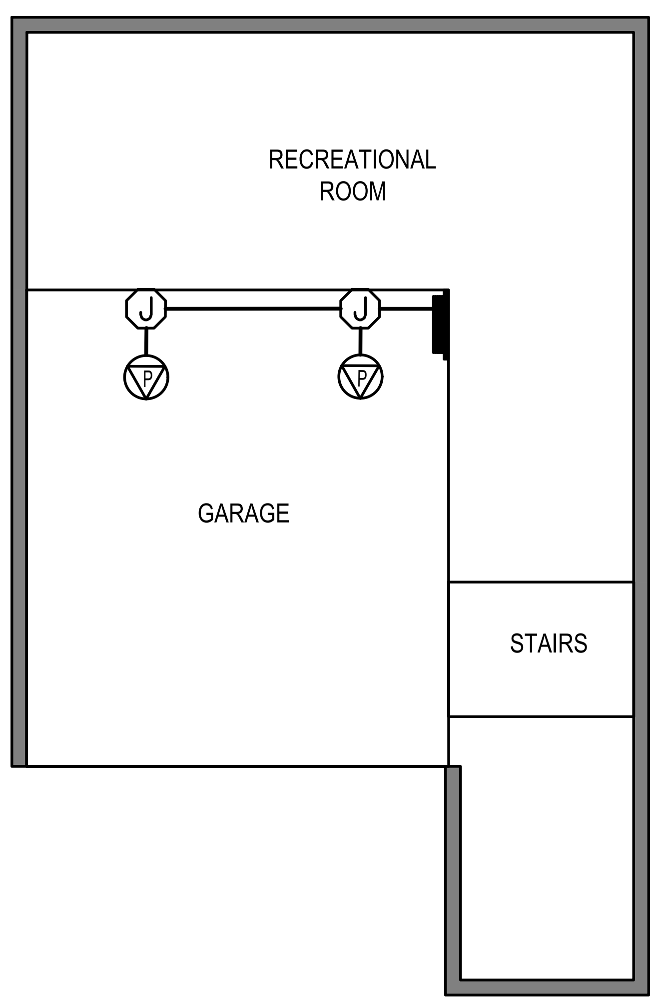
project

CLEAN AIR PARTNERSHIP
EV COSTING STUDY

drawing title

TOWNHOUSE
C1. 2-WAY ON 40A & C2. SERVICE MONITORING & C3. LOAD MISER

designed: TK	scale: AS NOTED	date: FEBRUARY, 2021	
drawn: TK	project no.: 2-21-050		
checked: VL	drawing no.: E-300		rev.: 02
approved: VL			



seal	consultant	project	designed	scale	date
	AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV COSTING STUDY	TK	AS NOTED	FEBRUARY, 2021
			drawn TK	project no. 2-21-050	
		drawing title: SINGLE FAMILY HOME C1. 2-WAY ON 40A & C2. LOAD SWITCHING	checked VL	drawing no. E-400	rev. 02
			approved VL		

Appendix D: Costing estimates

HIGH-RISE RESIDENTIAL

1. Dedicated circuits on 40A, TGS.v3

Total Level 2 EV-Ready Stalls:	74
Total Level 2 Circuits:	74
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	345
Final max. demand (kVA):	3,390

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	27.6kV splice	8,500	1	8,500	3	25,500
2	27.6kV fused disconnect (10T)	50,000	1	50,000	3	150,000
3	27.6kV : 208Y/120V, 500 kVA transformer	86,848	1	86,848	3	260,543
4	Circuit breaker for EV distribution board (2000A)	56,812	1	56,812	3	170,436
5	EV distribution board (2000A)	13,995	1	13,995	5	69,976
6	Circuit breaker for EV panelboard (400A)	6,512	5	32,559	3	97,677
7	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	528	30,956	3	92,869
8	Cabling from EV distribution board to panelboard (2 sets of 4#1/0)	42	75	3,192	2	6,384
9	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	604	21,132	5	105,661
10	EV panelboard breaker (40A)	232	74	17,134	2	34,268
11	400A MLO, 208Y/120V, 42 cct panelboard	3,121	5	15,604	3	46,813
12	Cabling from panelboard to EVSE (2#8)	4	5489	22,760	2	45,520
13	Cabling from panelboard to EVSE (2#6)	5	2297	11,710	2	23,419
14	Conduit from panelboard to EVSE (21mm (3/4"))	9	7785	67,607	5	338,036
15	Communication system	19,684	1	19,684	3	59,052
16	Utility meter	3,990	1	3,990	2	7980
	Cost ($)			462,484		1,534,134
	Cost ($ per stall)			6,250		20,732

HIGH-RISE RESIDENTIAL
2. 3-share on 40A, TGS.v3

Total Level 2 EV-Ready Stalls:	74
Total Level 2 Circuits:	26
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	173
Final max. demand (kVA):	3,219

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
	ELECTRICAL INFRASTRUCTURE					
1	27.6kV splice	8,500	1	8,500	3	25,500
2	27.6kV fused disconnect (10T)	50,000	1	50,000	3	150,000
3	27.6kV : 208Y/120V, 225 kVA transformer	69,515	1	69,515	3	208,544
4	Circuit breaker for EV distribution board (1200A)	23,296	1	23,296	3	69,889
5	EV distribution board (1200A)	12,585	1	12,585	5	62,923
6	Circuit breaker for EV panelboard (200A)	3,809	1	3,809	3	11,428
7	Circuit breaker for EV panelboard (225A)	3,734	2	7,468	3	22,403
8	Cabling from EV distribution board to panelboard (4#3/0)	30	110	3,304	2	6,608
9	Cabling from EV distribution board to panelboard (4#4/0)	35	221	7,622	2	15,245
10	Conduit from EV distribution board to panelboard (53mm (2"))	18	110	1,931	2	3,862
11	Conduit from EV distribution board to panelboard (63mm (2 1/2"))	24	221	5,287	2	10,575
12	EV panelboard breaker (40A)	232	26	6,020	2	12,040
13	225A MLO, 208Y/120V, 30 cct panelboard	2,184	3	6,551	2	13,103
14	Cabling from panelboard to EVSE (2#8)	4	2126	8,816	2	17,631
15	Cabling from panelboard to EVSE (2#6)	5	1076	5,487	2	10,974
16	Conduit from panelboard to EVSE (21mm (3/4"))	9	3202	27,806	5	139,032
17	Communication system	19,684	1	19,684	3	59,052
18	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			271,672		846,788
	Cost ($ per stall)			3,671		11,443

HIGH-RISE RESIDENTIAL
3. Dedicated circuits on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	369
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	1,719
Final max. demand (kVA):	4,765

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	27.6kV splice	8,500	1	8,500	3	25,500
2	27.6kV fused disconnect (30T)	50,000	1	50,000	3	150,000
3	27.6kV :208Y/120V, 2000 kVA transformer	116,226	1	116,226	3	348,678
4	Circuit breaker for EV feed distribution board (2000A)	56,812	1	56,812	3	170,436
5	EV feed distribution board (2000A)	13,995	1	13,995	5	69,976
6	Primary circuit breaker for EV distribution board (800A)	17,330	3	51,990	3	155,969
7	600V : 208Y/120V, 750 kVA transformer	26,450	3	79,349	3	238,046
9	EV distribution board (2500A)	15,863	3	47,588	5	237,940
10	Circuit breaker for EV panelboard (400A)	6,512	23	149,771	3	449,313
11	Circuit breaker for EV panelboard (200A)	3,809	1	3,809	3	11,428
12	Cabling from EV distribution board to panelboard (4#3/0)	29	69	2,019	2	4,038
13	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	2986	174,970	2	349,940
14	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	1598	112,438	2	224,877
16	Conduit from EV distribution board to panelboard (53mm (2"))	18	69	1,206	5	6,030
17	Conduit from EV distribution board to panelboard (2 sets of 53mm (2")	35	2986	104,512	5	522,560
18	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/	48	1598	76,566	5	382,832
19	EV panelboard breaker (40A)	232	369	85,438	2	170,876
20	400A MLO, 208Y/120V, 42 cct panelboard	3,121	23	71,780	3	215,341
21	225A MLO, 208Y/120V, 42 cct panelboard	2,184	1	2,184	3	6,551
22	Cabling from panelboard to EVSE (2#8)	4	28186	116,874	2	233,747

23	Cabling from panelboard to EVSE (2#6)	5	10020	53,407	2	106,815
24	Conduit from panelboard to EVSE (21mm (3/4"))	9	38205	331,768	5	1,658,839
25	Communication system	98,154	1	98,154	3	294,462
26	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			1,813,347		6,042,176
	Cost ($ per stall)			4,914		16,374

HIGH-RISE RESIDENTIAL
4. 3-share on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	131
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	872
Final max. demand (kVA):	3,918

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	27.6kV splice	8,500	2	17,000	3	51,000
2	27.6kV fused disconnect (10T)	50,000	2	100,000	3	300,000
3	27.6kV : 208Y/120V, 500 kVA transformer	86,848	2	173,696	3	521,087
4	Circuit breaker for EV distribution board (2000A)	56,812	2	113,624	3	340,873
5	EV distribution board (2000A)	13,995	2	27,990	5	139,952
6	Circuit breaker for EV panelboard (400A)	6,512	8	52,094	3	156,283
7	Circuit breaker for EV panelboard (200A)	3,809	1	3,809	3	11,428
8	Cabling from EV distribution board to panelboard (4#3/0)	29	102	2,980	2	5,961
9	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	735	43,070	2	86,139
10	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	682	48,023	2	96,046
12	Conduit from EV distribution board to panelboard (53mm (2"))	18	102	1,780	5	8,901
13	Conduit from EV distribution board to panelboard (2 sets of 53mm (2")	35	735	25,726	5	128,630
14	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/	48	682	32,702	5	163,509
15	EV panelboard breaker (40A)	232	131	30,332	2	60,663
17	400A MLO, 208Y/120V, 42 cct panelboard	3,121	8	24,967	3	74,901
18	225A MLO, 208Y/120V, 42 cct panelboard	2,184	1	2,184	3	6,551
19	Cabling from panelboard to EVSE (2#8)	4	1896	7,863	2	15,726
20	Cabling from panelboard to EVSE (2#6)	5	20531	109,438	2	218,876
21	Conduit from panelboard to EVSE (21mm (3/4"))	9	22428	194,759	5	973,794
22	Communication system	98,154	1	98,154	3	294,462
23	Utility meter	3,990	2	7,980	2	15,960

Cost ($)	1,118,171	3,670,742
Cost ($ per stall)	3,030	9,948

HIGH-RISE RESIDENTIAL
5. 4-share on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	96
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	639
Final max. demand (kVA):	3,685

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	27.6kV splice	8,500	1	8,500	3	25,500
2	27.6kV fused disconnect (10T)	50,000	1	50,000	3	150,000
3	27.6kV : 208Y/120V, 750 kVA transformer	92,400	1	92,400	3	277,200
4	Circuit breaker for EV distribution board (3000A)	68,803	1	68,803	3	206,408
5	EV distribution board (3000A)	17,730	1	17,730	5	88,651
6	Circuit breaker for EV panelboard (400A)	6,512	6	39,071	3	117,212
7	Circuit breaker for EV panelboard (200A)	3,809	3	11,428	3	34,285
8	Cabling from EV distribution board to panelboard (4#3/0)	29	59	1,730	2	3,461
9	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	456	26,726	2	53,452
10	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	1001	70,418	2	140,837
12	Conduit from EV distribution board to panelboard (53mm (2"))	18	59	1,034	5	5,168
13	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	456	15,964	5	79,820
14	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	1001	47,952	5	239,761
15	EV panelboard breaker (40A)	232	96	22,228	2	44,456
16	400A MLO, 208Y/120V, 42 cct panelboard	3,121	6	18,725	3	56,176
17	225A MLO, 208Y/120V, 42 cct panelboard	2,184	3	6,551	3	19,654
18	Cabling from panelboard to EVSE (2#8)	4	1535	6,367	2	12,734
19	Cabling from panelboard to EVSE (2#6)	5	12388	66,034	2	132,067
20	Conduit from panelboard to EVSE (21mm (3/4"))	9	13924	120,912	5	604,561
21	Communication system	98,154	1	98,154	3	294,462
22	Utility meter	3,990	1	3,990	2	7,980

Cost ($)	794,718	2,593,844
Cost ($ per stall)	2,154	7,029

HIGH-RISE RESIDENTIAL
6. 10-share on 80A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	43
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	572
Final max. demand (kVA):	3,618

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	27.6kV splice	8,500	1	8,500	3	25,500
2	27.6kV fused disconnect (10T)	50,000	1	50,000	3	150,000
3	27.6kV : 208Y/120V, 500 kVA transformer	86,848	1	86,848	3	260,543
4	Circuit breaker for EV distribution board (2000A)	56,812	1	56,812	3	170,436
5	EV distribution board (2000A)	13,995	1	13,995	5	69,976
6	Circuit breaker for EV panelboard (400A)	6,512	7	45,583	3	136,748
7	Circuit breaker for EV panelboard (200A)	3,809	2	7,619	3	22,857
8	Cabling from EV distribution board to panelboard (4#3/0)	29	358	10,479	2	20,958
9	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	479	28,072	2	56,144
10	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	682	48,023	2	96,046
12	Conduit from EV distribution board to panelboard (53mm (2"))	18	358	6,259	5	31,296
13	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	479	16,768	5	83,839
14	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	682	32,702	5	163,509
15	EV panelboard breaker (80A)	459	43	19,755	2	39,510
16	400A MLO, 208Y/120V, 42 cct panelboard	3,121	7	21,846	3	65,539
17	225A MLO, 208Y/120V, 42 cct panelboard	2,184	2	4,368	3	13,103
18	Cabling from panelboard to EVSE (2#4)	7	8497	60,283	2	120,567
19	Conduit from panelboard to EVSE (35mm (1 1/4"))	13	8497	114,133	5	570,667
20	Communication system	98,154	1	98,154	3	294,462
21	Utility meter	3,990	1	3,990	2	7,980

Cost ($)	734,189	2,399,680
Cost ($ per stall)	1,990	6,503

HIGH-RISE RESIDENTIAL

7. 4-share on 40A, 100% EV Ready w/ Service Monitoring

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	96
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	639
Final max. demand (kVA):	3,046

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV distribution board (1200A)	23,296	1	23,296	3	69,889
2	600V : 208Y/120V, 750 kVA transformer	26,450	1	26,450	3	79,349
3	EV distribution board (3000A)	17,730	1	17,730	5	88,651
4	Circuit breaker for EV panelboard (400A)	6,512	6	39,071	3	117,212
5	Circuit breaker for EV panelboard (200A)	3,809	3	11,428	3	34,285
6	Cabling from EV distribution board to panelboard (4#3/0)	29	59	1,730	2	3,461
7	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	774	45,377	2	90,754
8	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	682	48,023	2	96,046
9	Conduit from EV distribution board to panelboard (53mm (2"))	18	59	1,034	5	5,168
10	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	774	27,104	5	135,521
11	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	682	32,702	5	163,509
12	EV panelboard breaker (40A)	232	96	22,228	2	44,456
13	400A MLO, 208Y/120V, 42 cct panelboard	3,121	6	18,725	3	56,176
14	225A MLO, 208Y/120V, 42 cct panelboard	2,184	3	6,551	3	19,654
15	Cabling from panelboard to EVSE (2#8)	4	1535	6,367	2	12,734
16	Cabling from panelboard to EVSE (2#6)	5	12388	66,034	2	132,067
17	Conduit from panelboard to EVSE (21mm (3/4"))	9	13924	120,912	5	604,561
18	Communication system	98,154	1	98,154	3	294,462
19	Utility meter	3,990	1	3,990	2	7,980
20	EVEMS	15,000	1	15,000	3	45,000

Cost ($)	593,610	1,986,045
Cost ($ per stall)	1,609	5,382

TORONTO HIGH-RISE RESIDENTIAL

1. Dedicated circuits on 40A, TGS.v3

Total Level 2 EV-Ready Stalls:	74
Total Level 2 Circuits:	74
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	345
Final max. demand (kVA):	3,390

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	13.8kV splice	8,500	1	8,500	3	25,500
2	13.8kV fused disconnect (15T)	50,000	1	50,000	3	150,000
3	13.8kV : 208Y/120V, 500 kVA transformer	86,848	1	86,848	3	260,543
4	Circuit breaker for EV distribution board (2000A)	56,812	1	56,812	3	170,436
5	EV distribution board (2000A)	13,995	1	13,995	5	69,976
6	Circuit breaker for EV panelboard (400A)	6,512	5	32,559	3	97,677
7	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	528	30,956	3	92,869
8	Cabling from EV distribution board to panelboard (2 sets of 4#1/0)	42	75	3,192	2	6,384
9	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	604	21,132	5	105,661
10	EV panelboard breaker (40A)	232	74	17,134	2	34,268
11	400A MLO, 208Y/120V, 42 cct panelboard	3,121	5	15,604	3	46,813
12	Cabling from panelboard to EVSE (2#8)	4	5489	22,760	2	45,520
13	Cabling from panelboard to EVSE (2#6)	5	2297	11,710	2	23,419
14	Conduit from panelboard to EVSE (21mm (3/4"))	9	7785	67,607	5	338,036
15	Communication system	19,684	1	19,684	3	59,052
16	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			462,484		1,534,134
	Cost ($ per stall)			6,250		20,732

TORONTO HIGH-RISE RESIDENTIAL
2. 3-share on 40A, TGS.v3

Total Level 2 EV-Ready Stalls:	74
Total Level 2 Circuits:	26
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	173
Final max. demand (kVA):	3,219

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	13.8kV splice	8,500	1	8,500	3	25,500
2	13.8kV fused disconnect (15T)	50,000	1	50,000	3	150,000
3	13.8kV : 208Y/120V,225 kVA transformer	69,515	1	69,515	3	208,544
4	Circuit breaker for EV distribution board (1200A)	23,296	1	23,296	3	69,889
5	EV distribution board (1200A)	12,585	1	12,585	5	62,923
6	Circuit breaker for EV panelboard (200A)	3,809	1	3,809	3	11,428
7	Circuit breaker for EV panelboard (225A)	3,734	2	7,468	3	22,403
8	Cabling from EV distribution board to panelboard (4#3/0)	29	110	3,233	2	6,466
9	Cabling from EV distribution board to panelboard (4#4/0)	35	221	7,764	2	15,529
10	Conduit from EV distribution board to panelboard (53mm (2"))	18	110	1,931	2	3,862
11	Conduit from EV distribution board to panelboard (63mm (2 1/2"))	24	221	5,287	2	10,575
12	EV panelboard breaker (40A)	232	26	6,020	2	12,040
13	225A MLO, 208Y/120V, 30 cct panelboard	2,184	3	6,551	3	19,654
15	Cabling from panelboard to EVSE (2#8)	4	2126	8,816	2	17,631
16	Cabling from panelboard to EVSE (2#6)	5	1076	5,487	2	10,974
17	Conduit from panelboard to EVSE (21mm (3/4"))	9	3202	27,806	5	139,032
18	Communication system	19,684	1	19,684	3	59,052
19	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			271,743		853,481
	Cost ($ per stall)			3,672		11,534

TORONTO HIGH-RISE RESIDENTIAL
3. Dedicated circuits on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	369
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	1,719
Final max. demand (kVA):	4,765

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	13.8kV splice	8,500	1	8,500	3	25,500
2	13.8kV fused disconnect (65T)	50,000	1	50,000	3	150,000
3	13.8kV : 600Y/347V, 2000 kVA transformer	111,491	1	111,491	3	334,472
4	Circuit breaker for EV feed distribution board (2000A)	56,812	1	56,812	3	170,436
5	EV feed distribution board (2000A)	13,995	1	13,995	5	69,976
6	Primary circuit breaker for EV distribution board (800A)	17,330	3	51,990	3	155,969
7	600V : 208Y/120V, 750 kVA transformer	26,450	3	79,349	3	238,046
8	EV distribution board (2500A)	15,863	3	47,588	5	237,940
9	Circuit breaker for EV panelboard (400A)	6,512	23	149,771	3	449,313
10	Circuit breaker for EV panelboard (200A)	3,809	1	3,809	3	11,428
11	Cabling from EV distribution board to panelboard (4#3/0)	29	69	2,019	2	4,038
12	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	2986	174,970	2	349,940
13	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	1598	112,438	2	224,877
15	Conduit from EV distribution board to panelboard (53mm (2"))	18	69	1,206	5	6,030
16	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	2986	104,512	5	522,560
17	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	1598	76,566	5	382,832
18	EV panelboard breaker (40A)	232	369	85,438	2	170,876
19	400A MLO, 208Y/120V, 42 cct panelboard	3,121	23	71,780	3	215,341
20	225A MLO, 208Y/120V, 42 cct panelboard	2,184	1	2,184	3	6,551
21	Cabling from panelboard to EVSE (2#8)	4	28186	116,874	2	233,747

22	Cabling from panelboard to EVSE (2#6)	5	10020	53,407	2	106,815
25	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			1,808,612		6,027,969
	Cost ($ per stall)			4,901		16,336

TORONTO HIGH-RISE RESIDENTIAL
4. 3-share on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	131
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	872
Final max. demand (kVA):	3,918

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	13.8kV splice	8,500	1	8,500	3	25,500
2	13.8kV fused disconnect (15T)	50,000	1	50,000	3	150,000
3	13.8kV : 208Y/120V, 1000 kVA transformer	102,878	1	102,878	3	308,633
4	Circuit breaker for EV distribution board (3000A)	68,803	1	68,803	3	206,408
5	EV distribution board (3000A)	17,730	1	17,730	5	88,651
6	Circuit breaker for EV panelboard (400A)	6,512	8	52,094	3	156,283
7	Circuit breaker for EV panelboard (200A)	3,809	1	3,809	3	11,428
8	Cabling from EV distribution board to panelboard (4#3/0)	29	102	2,980	2	5,961
9	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	417	24,419	2	48,838
10	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	1001	70,418	2	140,837
12	Conduit from EV distribution board to panelboard (53mm (2"))	18	102	1,780	5	8,901
13	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	417	14,586	5	72,929
14	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	1001	47,952	5	239,761
15	EV panelboard breaker (40A)	232	131	30,332	2	60,663
17	400A MLO, 208Y/120V, 42 cct panelboard	3,121	8	24,967	3	74,901
18	225A MLO, 208Y/120V, 42 cct panelboard	2,184	1	2,184	3	6,551
19	Cabling from panelboard to EVSE (2#8)	4	1896	7,863	2	15,726
20	Cabling from panelboard to EVSE (2#6)	5	20531	109,438	2	218,876
21	Conduit from panelboard to EVSE (21mm (3/4"))	9	22428	194,759	5	973,794
22	Communication system	98,154	1	98,154	3	294,462
23	Utility meter	3,990	2	7,980	2	15,960

Cost ($)	941,626	3,125,062
Cost ($ per stall)	2,552	8,469

TORONTO HIGH-RISE RESIDENTIAL
5. 4-share on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	96
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	639
Final max. demand (kVA):	3,685

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	13.8kV splice	8,500	1	8,500	3	25,500
2	13.8kV fused disconnect (25T)	50,000	1	50,000	3	150,000
1	13.8kV : 208Y/120V, 750 kVA transformer	92,400	1	92,400	3	277,200
2	Circuit breaker for EV distribution board (2500A)	68,803	1	68,803	3	206,408
3	EV distribution board (2500A)	17,730	1	17,730	5	88,651
4	Circuit breaker for EV panelboard (400A)	6,512	6	39,071	3	117,212
5	Circuit breaker for EV panelboard (200A)	3,809	3	11,428	3	34,285
6	Cabling from EV distribution board to panelboard (4#3/0)	29	59	1,730	2	3,461
7	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	446	26,149	2	52,299
8	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	682	48,023	2	96,046
9	Conduit from EV distribution board to panelboard (53mm (2"))	18	59	1,034	5	5,168
10	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	446	15,619	5	78,097
11	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	682	32,702	5	163,509
12	EV panelboard breaker (40A)	232	96	22,228	2	44,456
13	400A MLO, 208Y/120V, 42 cct panelboard	3,121	6	18,725	3	56,176
14	225A MLO, 208Y/120V, 42 cct panelboard	2,184	3	6,551	3	19,654
15	Cabling from panelboard to EVSE (2#8)	4	1535	6,367	2	12,734
16	Cabling from panelboard to EVSE (2#6)	5	12388	66,034	2	132,067
17	Conduit from panelboard to EVSE (21mm (3/4"))	9	13924	120,912	5	604,561
18	Communication system	98,154	1	98,154	3	294,462
19	Utility meter	3,990	1	3,990	2	7,980

Cost ($)	756,151	2,469,925
Cost ($ per stall)	2,049	6,694

TORONTO HIGH-RISE RESIDENTIAL
6. 10-share on 80A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	43
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	572
Final max. demand (kVA):	3,618

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	13.8kV splice	8,500	1	8,500	3	25,500
2	13.8kV fused disconnect (15T)	50,000	1	50,000	3	150,000
3	13.8kV : 208Y/120V, 500 kVA transformer	86,848	1	86,848	3	260,543
4	Circuit breaker for EV distribution board (2000A)	56,812	1	56,812	3	170,436
5	EV distribution board (2000A)	13,995	1	13,995	5	69,976
6	Circuit breaker for EV panelboard (400A)	6,512	6	39,071	3	117,212
7	Circuit breaker for EV panelboard (200A)	3,809	3	11,428	3	34,285
8	Cabling from EV distribution board to panelboard (4#3/0)	29	358	10,479	2	20,958
9	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	479	28,072	2	56,144
10	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	682	48,023	2	96,046
12	Conduit from EV distribution board to panelboard (53mm (2"))	18	358	6,259	5	31,296
13	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	479	16,768	5	83,839
14	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	682	32,702	5	163,509
15	EV panelboard breaker (80A)	459	43	19,755	2	39,510
16	400A MLO, 208Y/120V, 42 cct panelboard	3,121	6	18,725	3	56,176
17	225A MLO, 208Y/120V, 42 cct panelboard	2,184	3	6,551	3	19,654
18	Cabling from panelboard to EVSE (2#4)	7	8497	60,283	2	120,567
19	Conduit from panelboard to EVSE (35mm (1 1/4"))	13	8497	114,133	5	570,667
20	Communication system	98,154	1	98,154	3	294,462
21	Utility meter	3,990	1	3,990	2	7,980

Cost ($)	730,550	2,388,762
Cost ($ per stall)	1,980	6,474

TORONTO HIGH-RISE RESIDENTIAL

7. 4-share on 40A, 100% EV Ready w/ Service Metering

Total Level 2 EV-Ready Stalls:	369
Total Level 2 Circuits:	96
Existing max. demand (kVA):	3,046
EVSE max. demand (kVA):	639
Final max. demand (kVA):	3,046

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV distribution board (1200A)	23,296	1	23,296	3	69,889
2	600V : 208Y/120V, 750 kVA transformer	26,450	1	26,450	3	79,349
3	EV distribution board (3000A)	17,730	1	17,730	5	88,651
4	Circuit breaker for EV panelboard (400A)	6,512	6	39,071	3	117,212
5	Circuit breaker for EV panelboard (200A)	3,809	3	11,428	3	34,285
6	Cabling from EV distribution board to panelboard (4#3/0)	29	59	1,730	2	3,461
7	Cabling from EV distribution board to panelboard (2 sets of 4#3/0)	59	479	28,072	2	56,144
8	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	70	682	48,023	2	96,046
9	Conduit from EV distribution board to panelboard (53mm (2"))	18	59	1,034	5	5,168
10	Conduit from EV distribution board to panelboard (2 sets of 53mm (2"))	35	479	16,768	5	83,839
11	Conduit from EV distribution board to panelboard (2 sets of 63mm (2 1/2"))	48	682	32,702	5	163,509
12	EV panelboard breaker (40A)	232	96	22,228	2	44,456
13	400A MLO, 208Y/120V, 42 cct panelboard	3,121	6	18,725	3	56,176
14	225A MLO, 208Y/120V, 42 cct panelboard	2,184	3	6,551	3	19,654
15	Cabling from panelboard to EVSE (2#8)	4	1535	6,367	2	12,734
16	Cabling from panelboard to EVSE (2#6)	5	12388	66,034	2	132,067
17	Conduit from panelboard to EVSE (21mm (3/4"))	9	13924	120,912	5	604,561
18	Communication system	98,154	1	98,154	3	294,462
19	Utility meter	3,990	1	3,990	2	7,980
20	EVEMS	15,000	1	15,000	3	45,000

Cost ($)	565,969	1,899,754
Cost ($ per stall)	1,534	5,148

MID-RISE RESIDENTIAL

1. Dedicated circuits on 40A, TGS.v3

Total Level 2 EV-Ready Stalls:	24
Total Level 2 Circuits:	21
Existing max. demand (kVA):	1,371
EVSE max. demand (kVA):	112
Final max. demand (kVA):	1,482

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV distribution board (200A)	3,809	1	3,809	3	11,428
2	600V : 208Y/120V, 150kVA transformer	6,922	1	6,922	3	20,765
3	Cabling from EV distribution board to panelboard (2 sets of 4#250)	79	226	17,844	2	35,687
4	Conduit from panelboard to EVSE (2 sets of 63mm (2 1/2"))	48	226	10,848	5	54,241
5	EV panelboard breaker (40A)	232	21	4,862	2	9,725
6	600A MLO, 208Y/120V, 42 cct panelboard	2,184	1	2,184	3	6,551
7	Cabling from panelboard to EVSE (2#8)	4	2539	10,530	2	21,059
8	Conduit from panelboard to EVSE (21mm (3/4"))	9	2539	22,051	5	110,257
9	Communication system	6,384	1	6,384	3	19,152
10	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			89,424		296,846
	Cost ($ per stall)			3,726		12,369

MID-RISE RESIDENTIAL
2. 3-share on 40A, TGS.v3

Total Level 2 EV-Ready Stalls:	24
Total Level 2 Circuits:	7
Existing max. demand (kVA):	1,371
EVSE max. demand (kVA):	47
Final max. demand (kVA):	1,417

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV distribution board (100A)	1,770	1	1,770	3	5,309
2	600V : 208Y/120V, 75kVA transformer	4,348	1	4,348	3	13,043
3	Cabling from transformer to panelboard (4#3/0)	42	226	9,576	2	19,153
4	Conduit from panelboard to EVSE (53mm (2"))	35	226	7,925	5	39,623
5	EV panelboard breaker (40A)	232	7	1,621	2	3,242
6	225A MLO, 208Y/120V, 42 cct panelboard	2,184	1	2,184	3	6,551
7	Cabling from panelboard to EVSE (2#8)	4	725	3,007	2	6,013
8	Conduit from panelboard to EVSE (21mm (2"))	11	725	7,750	5	38,750
9	Communication system	6,384	1	6,384	3	19,152
10	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			48,553		158,816
	Cost ($ per stall)			2,023		6,617

MID-RISE RESIDENTIAL
3. Dedicated circuits on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls: 104
Total Level 2 Circuits: 104
Existing max. demand (kVA): 1,371
EVSE max. demand (kVA): 485
Final max. demand (kVA): 1,855

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Increased rating of 27.6kV : 600Y/347V main transformer (1500kVA to 2000kVA)	10,676	1	10,676	8	80,066
2	Increased rating of main circuit breaker (1600A to 2000A)	4,447	1	4,447	3	13,340
3	Increase rating of main distribution board (1600A to 2000A)	1,145	1	1,145	8	8,585
4	Primary circuit breaker for EV feed (800A)	12,033	1	12,033	3	36,099
5	600V : 208Y/120V, 500 kVA transformer	16,731	1	16,731	8	125,483
7	EV distribution board (2500A)	15,863	1	15,863	5	79,313
8	Circuit breaker for EV panelboard (600A)	9,261	4	37,045	3	111,136
9	Circuit breaker for EV panelboard (400A)	6,512	2	13,024	3	39,071
10	EV panelboard breaker (40A)	232	104	24,080	2	48,160
11	600A MLO, 208Y/120V, 42 cct panelboard	4,777	4	19,106	3	57,318
12	400A MLO, 208Y/120V, 42 cct panelboard	3,121	2	6,242	3	18,725
13	Cabling from EV distribution board to panelboard (2 sets of 4#250)	79	1014	79,909	2	159,817
14	Cabling from EV distribution board to panelboard (2 sets of 4#4/0)	69	551	38,078	2	76,156
15	Conduit from panelboard to EVSE (2 sets of 63mm (2 1/2"))	48	1565	74,994	5	374,971
16	Cabling from panelboard to EVSE (2#8)	4	6070	25,168	2	50,335
17	Cabling from panelboard to EVSE (2#6)	5	7684	39,177	2	78,355
18	Conduit from EV switchboard to panelboard (21mm/ (3/4)")	9	13753	119,431	5	597,154
19	Communication system	27,664	1	27,664	3	82,992
20	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			568,801		2,045,057

Cost ($ per stall)	5,469	19,664

MID-RISE RESIDENTIAL
4. 3-share on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	104
Total Level 2 Circuits:	35
Existing max. demand (kVA):	1,371
EVSE max. demand (kVA):	233
Final max. demand (kVA):	1,603

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Increased rating of 27.6kV : 600Y/347V main transformer (1500kVA to 2000kVA)	10,676	1	10,676	8	80,066
2	Increased rating of main breaker (1600A to 2000A)	4,447	1	4,447	3	13,340
3	Increase rating of main distribution board (1600A to 2000A)	1,145	1	1,145	8	8,585
4	Circuit breaker for EV switchboard (400A)	6,512	1	6,512	3	19,535
5	600V : 208Y/120V, 300 kVA transformer	11,913	1	11,913	3	35,739
6	EV distribution board (1200A)	12,585	1	12,585	5	62,923
7	Circuit breaker for EV panelboard (400A)	6,512	2	13,024	3	39,071
8	Circuit breaker for EV panelboard (200A)	3,809	1	3,809	3	11,428
9	Cabling from switchboard to panelboard (2 sets of 4#3/0)	59	505	29,610	2	59,221
10	Cabling from switchboard to panelboard (4#3/0)	29	266	7,787	2	15,574
11	Conduit from EV switchboard to panelboard (2 sets of 53mm (2"))	35	505	17,687	5	88,433
12	Conduit from EV switchboard to panelboard (53mm (2"))	18	266	4,651	5	23,257
13	EV panelboard breaker (40A)	232	35	8,104	2	16,208
14	400A MLO, 208Y/120V, 42 cct panelboard	3,121	2	6,242	3	18,725
15	225A MLO, 208Y/120V, 42 cct panelboard	2,184	1	2,184	3	6,551
16	Cabling from panelboard to EVSE (2#8)	4	3720	15,427	2	30,854
17	Cabling from panelboard to EVSE (2#6)	5	1539	7,846	2	15,691
18	Conduit from panelboard to EVSE (21mm (3/4"))	9	5259	45,670	5	228,349
19	Communication system	27,664	1	27,664	3	82,992
20	Utility meter	3,990	1	3,990	2	7,980

Cost ($)	240,971	864,523
Cost ($ per stall)	2,317	8,313

MID-RISE RESIDENTIAL
5. 4-share on 40A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	104
Total Level 2 Circuits:	26
Existing max. demand (kVA):	1,371
EVSE max. demand (kVA):	173
Final max. demand (kVA):	1,544

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Increased rating of 27.6kV : 600Y/347V main transformer (1500kVA to 2000kVA)	10,676	1	10,676	8	80,066
2	Increased rating of circuit breaker for main switchboard (1600A to 2000A)	4,447	1	4,447	3	13,340
3	Increased rating of main switchboard (1600A to 2000A)	1,145	1	1,145	8	8,585
4	Circuit breaker for EV distribution board (400A)	6,512	1	6,512	3	19,535
5	600V : 208Y/120V, 225 kVA transformer	9,496	1	9,496	3	28,487
6	EV distribution board (1200A)	12,585	1	12,585	5	62,923
7	Circuit breaker for EV panelboard (400A)	6,512	1	6,512	5	32,559
8	Circuit breaker for EV panelboard (200A)	3,809	2	7,619	3	22,857
9	Cabling from switchboard to panelboard (2 sets of 4#3/0)	59	266	15,574	2	31,149
10	Cabling from switchboard to panelboard (4#3/0)	29	505	14,805	2	29,610
11	Conduit from EV switchboard to panelboard (2 sets of 53mm (2"))	35	266	9,303	5	46,514
12	Conduit from EV switchboard to panelboard (53mm (2"))	18	505	8,843	5	44,217
13	EV panelboard breaker (40A)	232	26	6,020	2	12,040
14	400A MLO, 208Y/120V, 42 cct panelboard	3,121	1	3,121	3	9,363
15	225A MLO, 208Y/120V, 42 cct panelboard	2,184	2	4,368	3	13,103
16	Cabling from panelboard to EVSE (2#8)	4	2992	12,407	2	24,814
17	Conduit from panelboard to EVSE (21mm (3/4"))	9	2992	25,983	5	129,915
18	Communication system	27,664	1	27,664	3	82,992
19	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			191,068		700,048

Cost ($ per stall)	1,837	6,731

MID-RISE RESIDENTIAL
6. 10-share on 80A, 100% EV Ready

Total Level 2 EV-Ready Stalls:	104
Total Level 2 Circuits:	11
Existing max. demand (kVA):	1,371
EVSE max. demand (kVA):	146
Final max. demand (kVA):	1,517

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Increased rating of 27.6 kV : 600Y/347V main transformer (1500kVA to 2000kVA)	10,676	1	10,676	8	80,066
2	Increased rating of circuit breaker for main switchboard (1600A to 2000A)	4,447	1	4,447	3	13,340
3	Increased rating of main switchboard (1600A to 2000A)	1,145	1	1,145	8	8,585
4	Circuit breaker for EV distribution board (200A)	3,809	1	3,809	3	11,428
5	600V : 208Y/120V, 150 kVA transformer	6,922	1	6,922	3	20,765
6	EV distribution board (600A)	10,194	1	10,194	5	50,971
7	Circuit breaker for EV panelboard (400A)	6,512	2	13,024	3	39,071
8	Cabling from switchboard to panelboard (2 sets of 4#3/0)	60	440	26,596	2	53,192
9	Conduit from EV switchboard to panelboard (2 sets of 53mm (2"))	35	440	15,390	5	76,948
10	EV panelboard breaker (80A)	459	11	5,054	2	10,107
11	400A MLO, 208Y/120V, 42 cct panelboard	3,121	2	6,242	3	18,725
12	Cabling from panelboard to EVSE (2#4)	7	1083	7,165	2	14,331
13	Conduit from panelboard to EVSE (35mm (1 1/4"))	13	1083	14,542	5	72,710
14	Communication system	27,664	1	27,664	3	82,992
15	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			156,858		561,213
	Cost ($ per stall)			1,508		5,396

MID-RISE RESIDENTIAL
7. 4-share on 40A, 100% EV Ready w/ Service Monitoring

Total Level 2 EV-Ready Stalls:	104
Total Level 2 Circuits:	26
Existing max. demand (kVA):	1,371
EVSE max. demand (kVA):	173
Final max. demand (kVA):	1,544

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV distribution board (400A)	6,512	1	6,512	3	19,535
2	600V : 208Y/120V, 225 kVA transformer	9,496	1	9,496	3	28,487
3	EV distribution board (1200A)	12,585	1	12,585	5	62,923
4	Circuit breaker for EV panelboard (400A)	6,512	1	6,512	3	19,535
5	Circuit breaker for EV panelboard (200A)	3,809	2	7,619	3	22,857
6	Cabling from switchboard to panelboard (2 sets of 4#3/0)	60	266	16,077	2	32,153
7	Cabling from switchboard to panelboard (4#3/0)	29	505	14,805	2	29,610
8	Conduit from EV switchboard to panelboard (2 sets of 53mm (2"))	35	266	9,303	5	46,514
9	Conduit from EV switchboard to panelboard (53mm (2"))	18	505	8,843	5	44,217
10	EV panelboard breaker (40A)	232	26	6,020	2	12,040
11	400A MLO, 208Y/120V, 42 cct panelboard	3,121	1	3,121	3	9,363
12	225A MLO, 208Y/120V, 42 cct panelboard	2,184	2	4,368	3	13,103
13	Cabling from panelboard to EVSE (2#8)	4	2992	12,407	2	24,814
14	Conduit from panelboard to EVSE (21mm (3/4"))	9	2992	25,983	5	129,915
15	Communication system	27,664	1	27,664	3	82,992
16	Utility meter	3,990	1	3,990	2	7,980
17	EVEMS	15,000	1	15,000	3	45,000
	Cost ($)			190,303		586,038
	Cost ($ per stall)			1,830		5,635

TOWNHOUSE
1. 2-share on 40A. 100% EV Ready

Total Level 2 EV-Ready Stalls:	52
Total Level 2 Circuits:	26
Existing max. demand (kVA):	164
EVSE max. demand (kVA):	173
Final max. demand (kVA):	337

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Increased rating of panelboard circuit breaker (100A to 200A)	2,040	26	53,036	3	159,108
2	Increaed rating of cabling from switchboard (4#3 to 4#3/0)	19	1300	25,011	2	50,023
3	Increaed rating of conduit from switchboard (35mm (1 1/4") to 53mm (2"))	4	1300	5,293	5	26,463
4	Circuit breaker for EV panelboard (40A)	232	26	6,020	2	12,040
5	Increased rating of panelboard (100A to 225A)	535	26	13,913	3	41,738
6	Cabling from panelboard to EVSE (2#8)	2	783	1,402	2	2,805
7	Conduit from panelboard to EVSE (21mm (3/4"))	9	867	7,526	5	37,630
8	Communication system	13,832	1	13,832	3	41,496
	Cost ($)			126,033		371,302
	Cost ($ per stall)			2,424		7,140

TOWNHOUSE
2. Service Monitoring, 100% EV Ready

Total Level 2 EV-Ready Stalls:	52
Total Level 2 Circuits:	26
Existing max. demand (kVA):	164
EVSE max. demand (kVA):	0
Final max. demand (kVA):	164

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV panelboard (40A)	232	26	6,020	2	12,040
2	Cabling from panelboard to EVSE (2#8)	4	783	3,245	2	6,490
3	Conduit from panelboard to EVSE (21mm (3/4"))	9	783	6,796	5	33,980
4	Communication system	13,832	1	13,832	3	41,496
5	Electric Vehicle Energy Monitoring System (EVEMS)	1,330	26	34,580	3	103,740
	Cost ($)			64,473		197,746
	Cost ($ per stall)			1,240		3,803

TOWNHOUSE
3. Load Miser, 100% EV Ready

Total Level 2 EV-Ready Stalls:	52
Total Level 2 Circuits:	26
Existing max. demand (kVA):	164
EVSE max. demand (kVA):	0
Final max. demand (kVA):	164

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV panelboard (40A)	232	26	6,020	2	12,040
2	Cabling from panelboard to EVSE (2#8)	4	783	3,245	2	6,490
3	Conduit from panelboard to EVSE (21mm (3/4"))	9	783	6,796	5	33,980
4	Communication system	13,832	1	13,832	3	41,496
5	Load Miser	1,000	26	26,000	3	78,000
	Cost ($)			55,893		172,006
	Cost ($ per stall)			1,075		3,308

SINGLE FAMILY DWELLING
1. 2-share on 40A. 100% EV Ready

Total Level 2 EV-Ready Stalls:	44
Total Level 2 Circuits:	22
Existing max. demand (kVA):	177
EVSE max. demand (kVA):	169
Final max. demand (kVA):	346

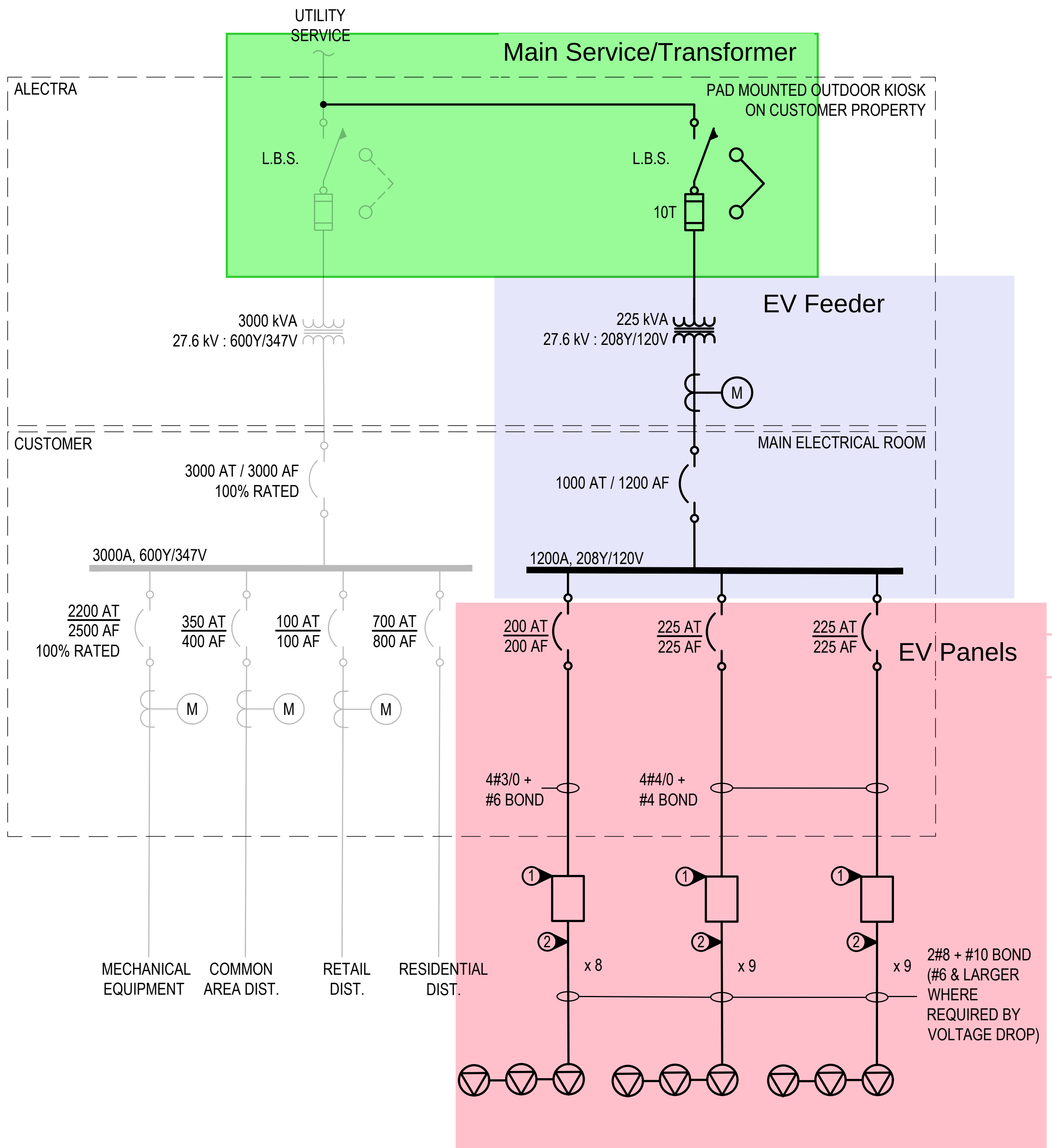
No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Increased rating of utility circuit breaker (100A to 150A)	2,040	22	44,877	3	134,630
2	Increaed rating of cabling to panelboard (4#3 to 4#1/0)	11	132	1,464	2	2,927
3	Increaed rating of conduit to panelboard (35mm (1 1/4") to 53mm (2"))	4	132	537	5	2,687
4	Circuit breaker for EV panelboard (40A)	232	22	5,094	2	10,188
5	Cabling from panelboard to EVSE (2#8)	4	326	1,353	2	2,706
6	Conduit from panelboard to EVSE (21mm (3/4"))	9	326	2,833	5	14,167
	Cost ($)			56,158		167,305
	Cost ($ per stall)			1,276		3,802

SINGLE FAMILY DWELLING
2. Load Switching, 100% EV Ready

Total Level 2 EV-Ready Stalls:	44
Total Level 2 Circuits:	22
Existing max. demand (kVA):	177
EVSE max. demand (kVA):	0
Final max. demand (kVA):	177

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV panelboard (40A)	232	22	5,094	2	10,188
2	Cabling from panelboard to EVSE (2#8)	4	326	1,353	2	2,706
3	Conduit from panelboard to EVSE (21mm (3/4"))	9	326	2,833	5	14,167
4	Load Switching	1,000	22	22,000	3	66,000
	Cost ($)			31,280		93,061
	Cost ($ per stall)			711		2,115

Appendix E: Cost categories



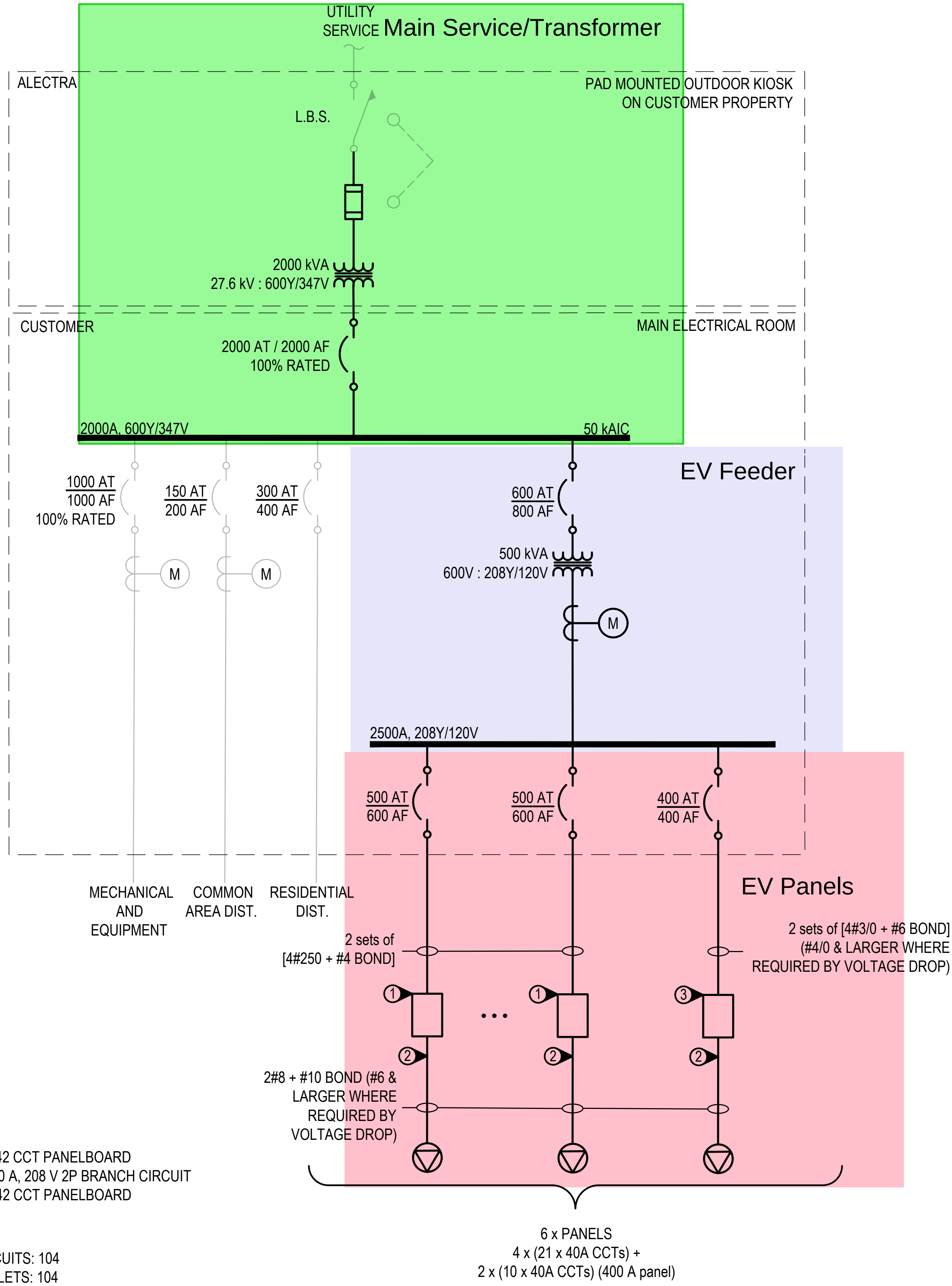
KEYNOTES:

1. 225A, 208Y/120V 42 CCT PANELBOARD
2. 3 EV STALLS PER 40 A, 208 V, 2P BRANCH CIRCUIT

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 26
B) TOTAL EVSE OUTLETS: 74

consultant	project	designed	scale	date
AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	TE	AS NOTED	
		drawn: TE	project no.: 2-21-050	
	drawing title: HIGH RISE C2. 3-SHARE ON 40A, TGS.v3	checked	drawing no.: E-02	rev.: 3
		approved		



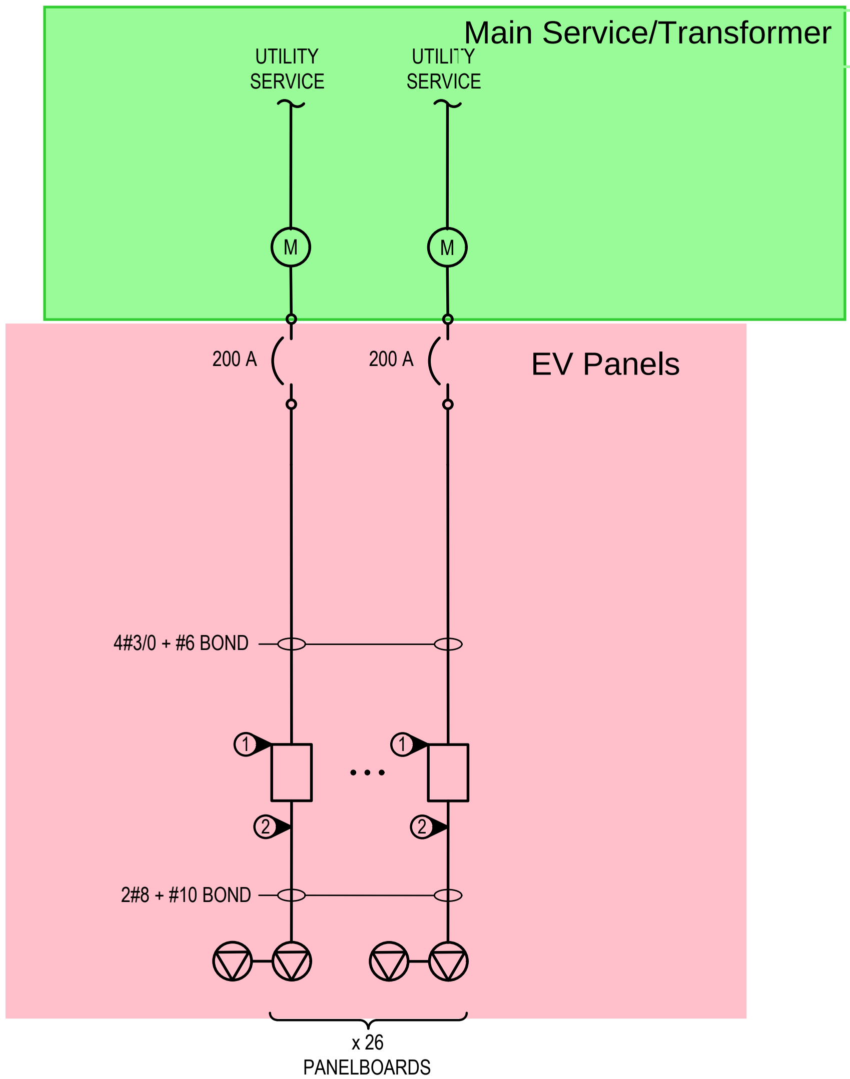
KEYNOTES:

1. 600 A, 208Y/120V 42 CCT PANELBOARD
2. 1 EV STALL PER 40 A, 208 V 2P BRANCH CIRCUIT
3. 400 A, 208Y/120V 42 CCT PANELBOARD

GENERAL NOTES:

A) TOTAL EVSE CIRCUITS: 104
B) TOTAL EVSE OUTLETS: 104

consultant AES Designing A Better Tomorrow 505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4 604.569.6500 | www.aesengr.com CALGARY | VANCOUVER | VICTORIA	project CLEAN AIR PARTNERSHIP EV CHARGING COSTING STUDY	designed TE	scale AS NOTED	date		
		drawn TE	project no. 2-21-050			
	drawing title MID RISE C3. DEDICATED CIRCUITS ON 40A, 100% EV READY	checked	drawing no. E-23		rev. 3	
		approved				



KEYNOTES:

1. 225A, 208Y/120V 42 CCT PANELBOARD
2. 2 EV STALLS PER 40 A, 208 V BRANCH CIRCUIT

consultant

AES
Designing A Better Tomorrow

505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | **VANCOUVER** | VICTORIA

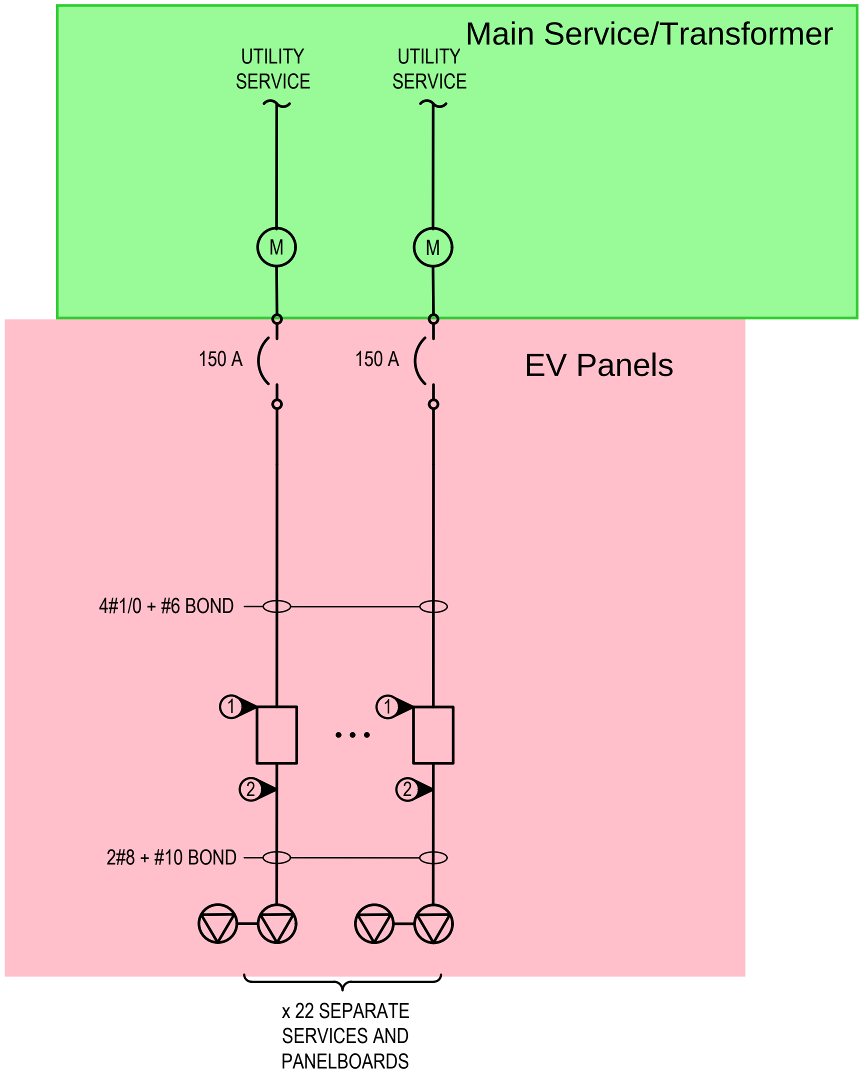
project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

TOWNHOUSE
C1. 2-SHARE ON 40A, 100% EV READY

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-31	3



KEYNOTES:

1. 225A, 120/240V 42 CCT PANELBOARD
2. 2 EV STALLS PER 40 A, 208 V BRANCH CIRCUIT

consultant

AES
Designing A Better Tomorrow
505 Burrard Street, Suite 950, Vancouver, BC V7X 1M4
604.569.6500 | www.aesengr.com
CALGARY | VANCOUVER | VICTORIA

project

CLEAN AIR PARTNERSHIP
EV CHARGING COSTING STUDY

drawing title

SINGLE FAMILY HOME
C1. 2-SHARE ON 40A, 100% EV READY

designed	scale	date
TE	AS NOTED	
drawn	project no.	
TE	2-21-050	
checked	drawing no.	rev.
approved	E-41	3