Greater Toronto Hamilton Area EV Ready Residential Parking New Construction Costing Study

Prepared for the Clean Air Partnership

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Low Carbon Strategies

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ABOUT THIS STUDY

- The Clean Air Partnership (CAP) is supporting local governments in the GTHA considering “EV Ready” requirements for new residential developments.
  - CAP commissioned *Electric Vehicle Charging Infrastructure Costing Study*.
  - Generous support from The Atmospheric Fund.

- This report was prepared by AES Engineering Ltd.
  - Mulvey + Banani International Inc (MBII), provided local design advising and peer review.

OUTLINE

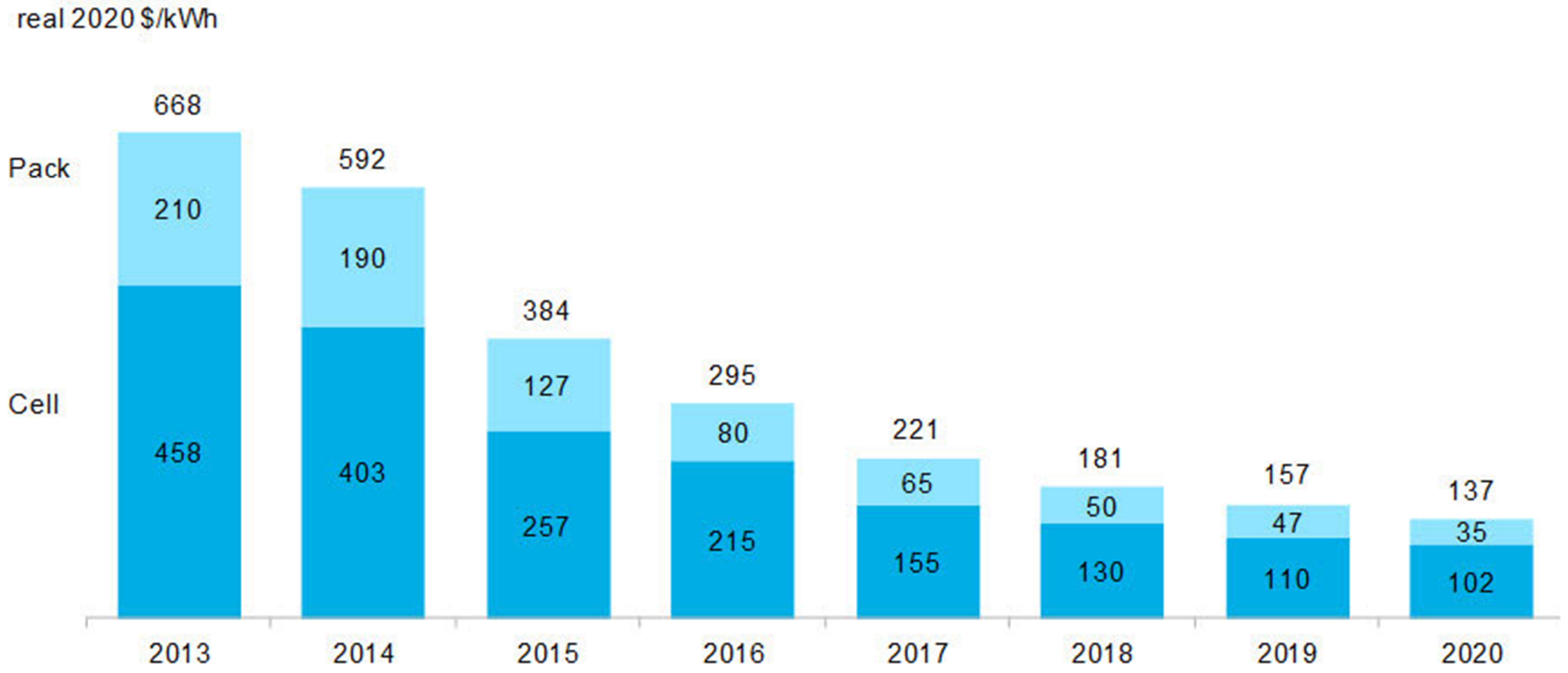
- Background
  - Quick review of EV trends & context
  - Importance of access to home charging
  - About "EV Ready" parking
  - About EV Energy Management Systems

- EV Ready Residential Parking Costing Study
  - Overview of building archetypes
  - Design scenarios
  - Results

Image Credit: Jason Zytynsky

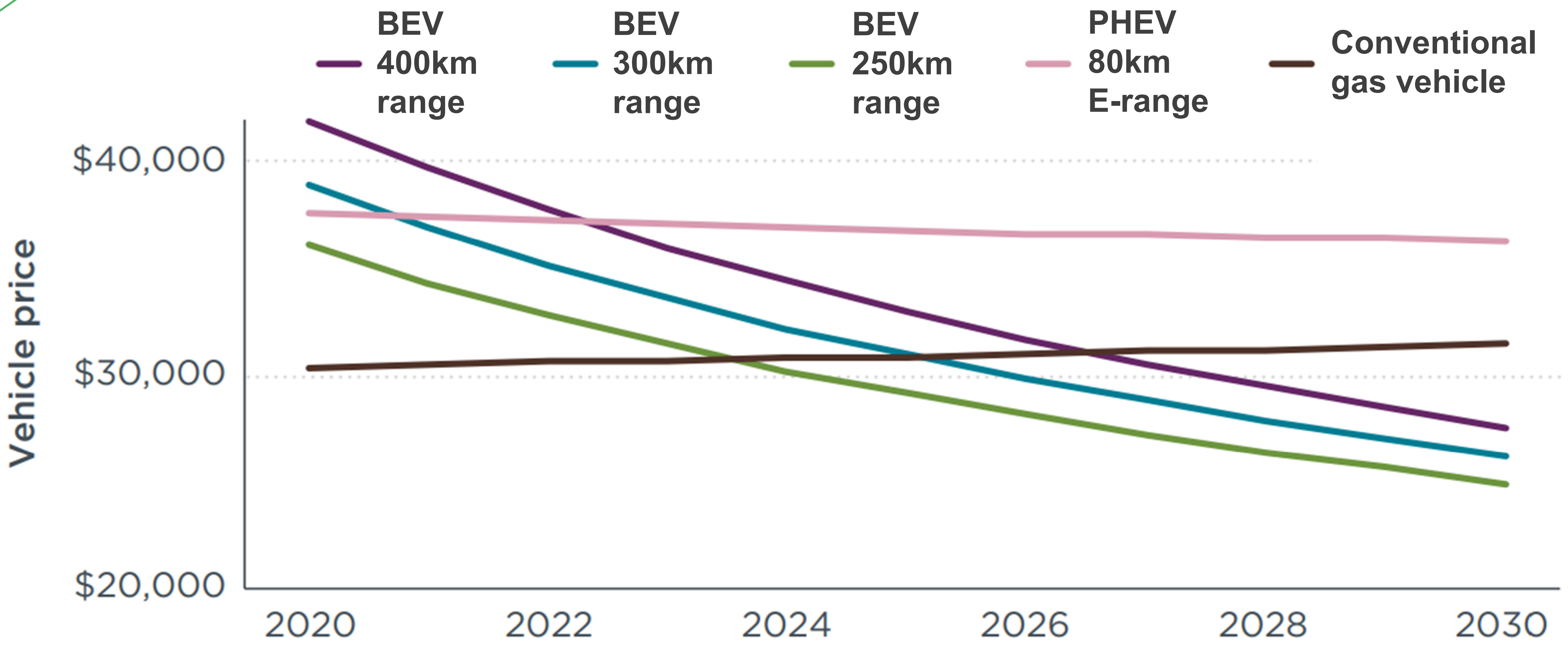
EV TRENDS & CONTEXT

EV'S Li-ION BATTERY COSTS ARE DECLINING



Source: BloombergNEF

EV "PRICE PARITY" (NO INCENTIVES)



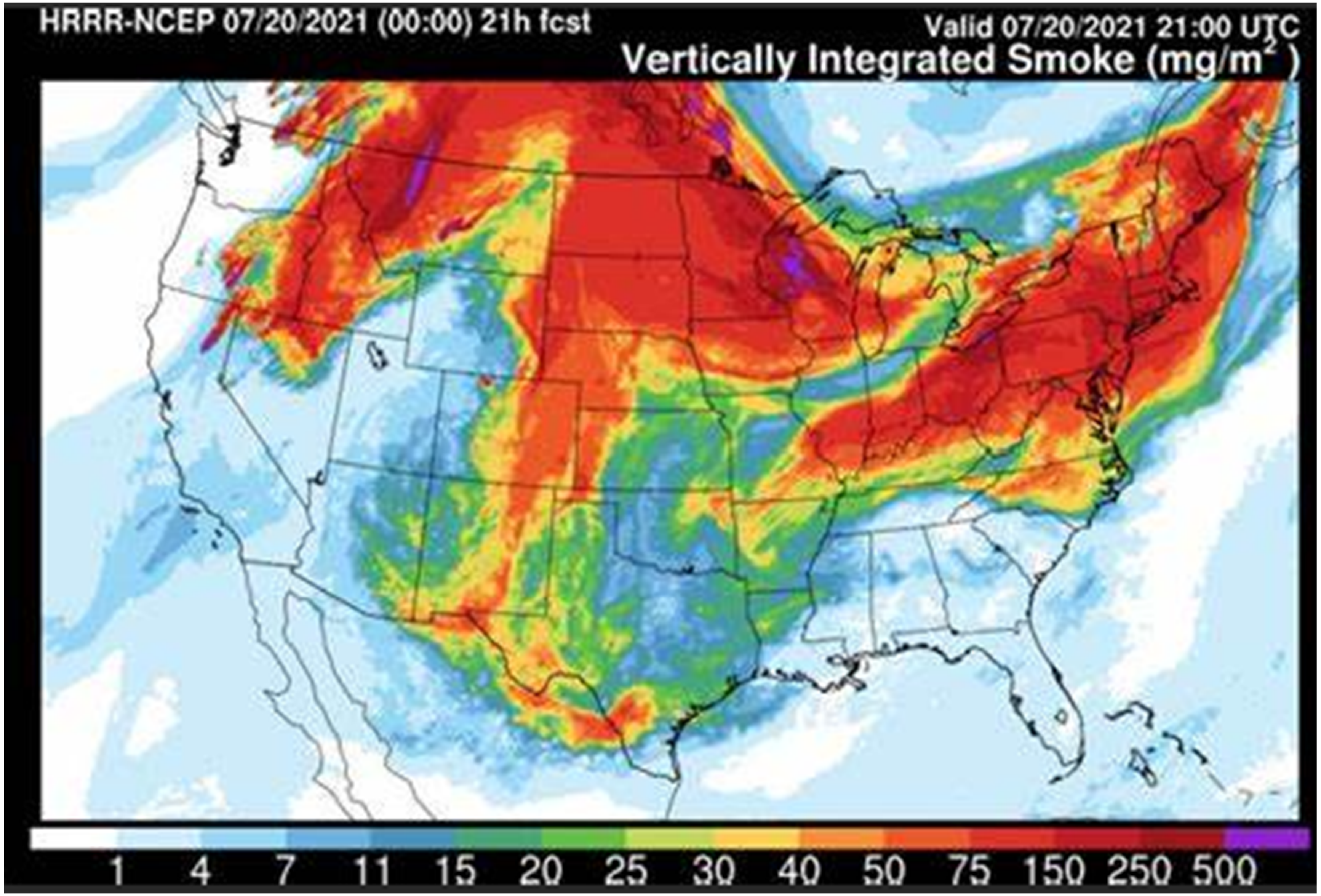
Source: International Council on Clean Transportation. April 2019. *Update on electric vehicle costs in the United States through 2030.*

POLICY IS DRIVING EV ADOPTION

- In June 2021, the Federal Government announced it would adopt **requirements for 100% of passenger vehicle sales to be zero emissions (e.g. EVs) by 2035.**

Source: Government of Canada. June 2021*. Building a green economy: Government of Canada to require 100% of car and passenger truck sales be zero-emission by 2035 in Canada*. https://www.canada.ca/en/transport-canada/news/2021/06/building-a-green-economy-government-of-canada-to-require-100-of-car-and-passenger-truck-sales-be-zero-emission-by-2035-in-canada.html

Image Credit: Dennis Jarvis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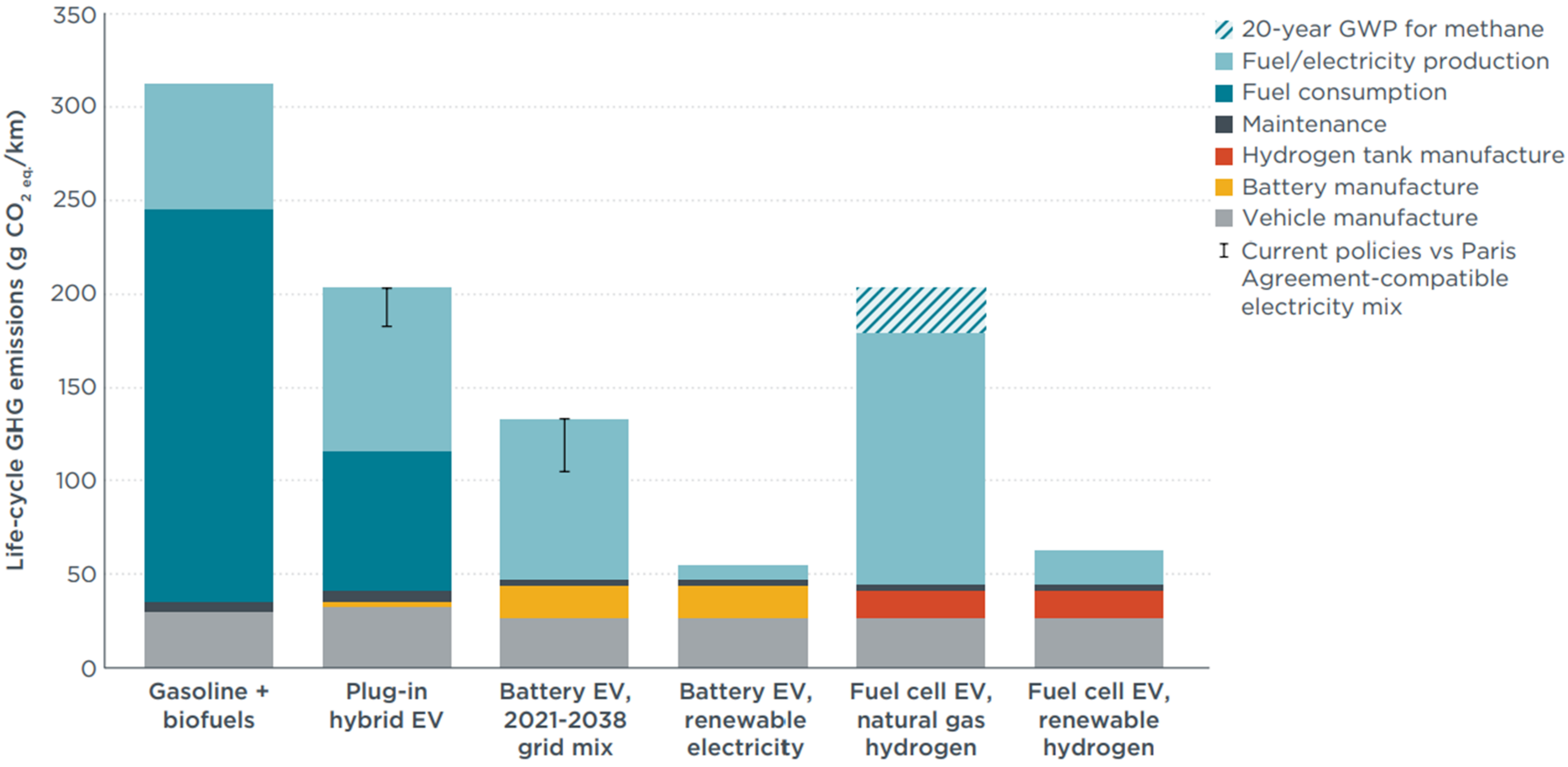
Valid 07/20/2021 21:00 UTC
Vertically Integrated Smoke (mg/m²)
1 4 7 11 15 20 25 30 40 50 75 150 250 500

EVs ARE A CLIMATE SOLUTION

International Council on Clean Transportation Estimate for Lifecycle Emissions – North America SUV



Source: ICCT. July 2021. [A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars (theicct.org)]

THE NEED TO SUPPORT ACCESS TO EV CHARGING

WHERE DO WE CHARGE?

- “At Home” charging critical to enabling EV adoption
- “At Work” and publicly-accessible “On the Go” charging are important supplements

Image: Argonne National Laboratory

IT'S COSTLY & COMPLICATED TO RETROFIT CHARGING INTO MURBs

- Incremental EV charging retrofits are expensive

- Comprehensive (e.g. 100%) EV Ready retrofits can significantly lower costs per parking space.
  - However, it is challenging for condominium associations & rental building owners to invest in these projects.
  - Complicated. Owners lack of expertise.
  - Significant upfront costs.

- It is best to future-proof buildings for EVs at time of construction.

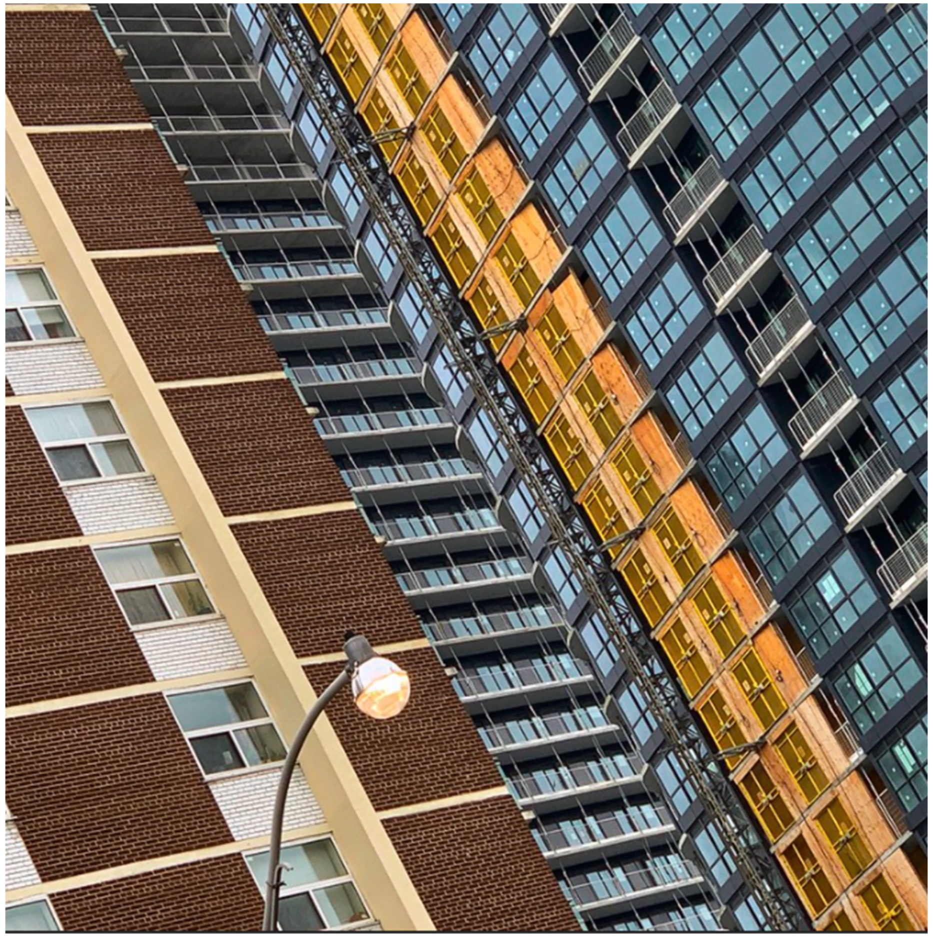


Image Credit: Timothy Neesam.

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ABOUT EV ENERGY MANAGEMENT SYSTEMS

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EV Energy Management Systems (EVEMS)

- EVEMS monitor and control EV loads.
- Advantages include:
  - Reduction in electrical capacity and associated electrical infrastructure costs necessary to provide EV charging.
  - Ability to accommodate greater amount of EV charging within finite electrical capacity of existing buildings.
  - Managing EV loads to maximize value – e.g. avoid demand charges; respond to dynamic rates; respond to utility demand response events; use variable renewable energy; etc.
- EVEMS are important to enabling high levels of EV charging in many MURBs, workplaces, and fleet parking applications.

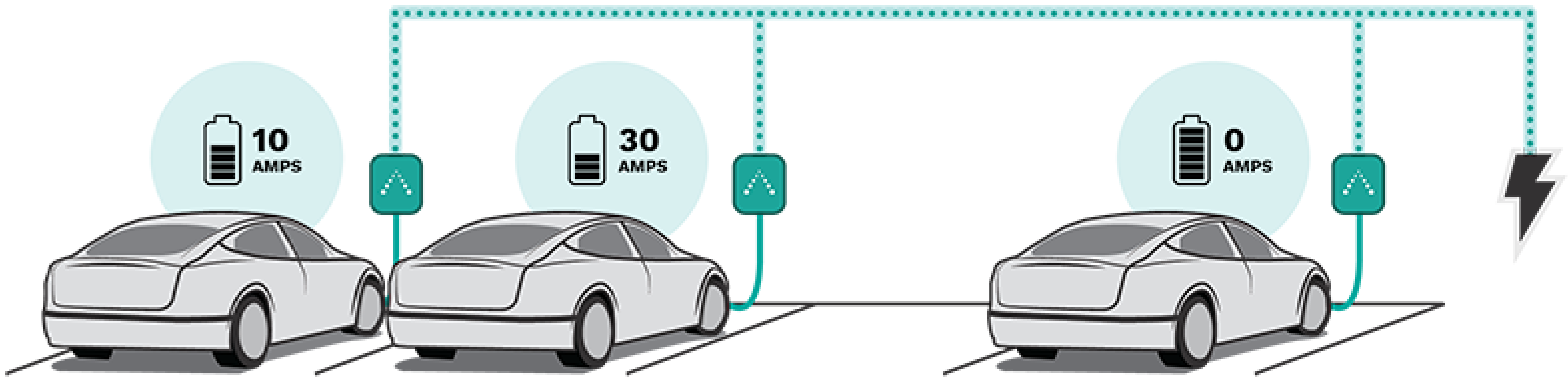
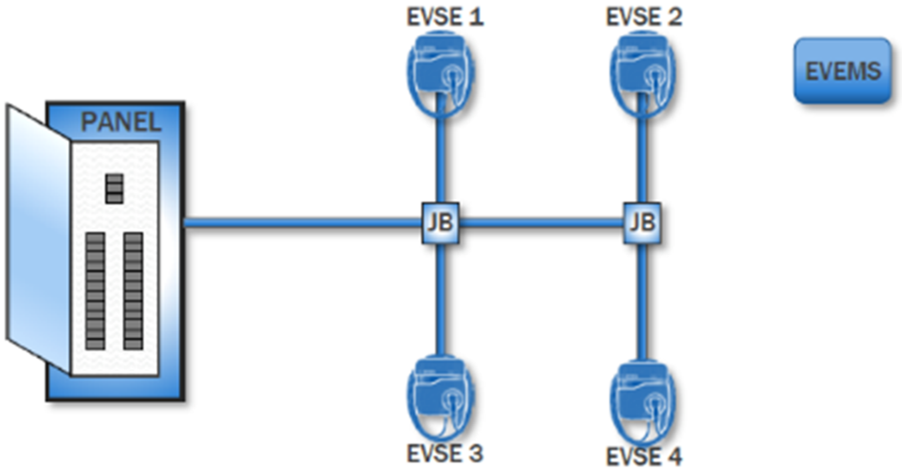


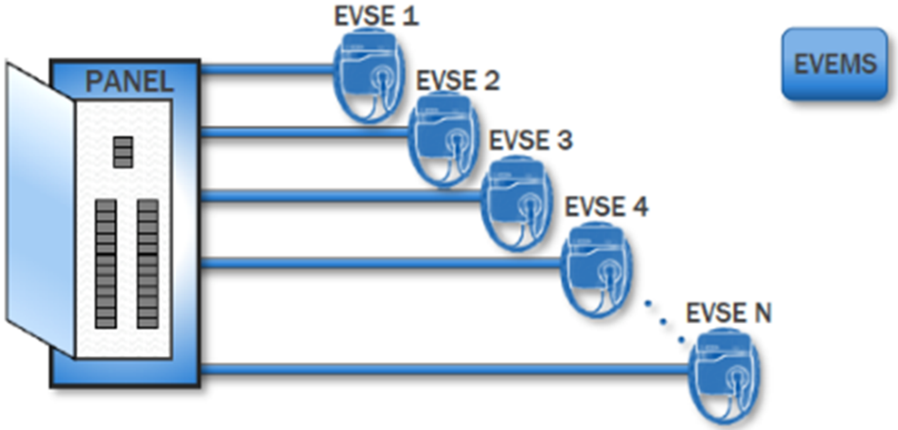
Image Source: Evercharge.

Some Electrical Infrastructure Configurations

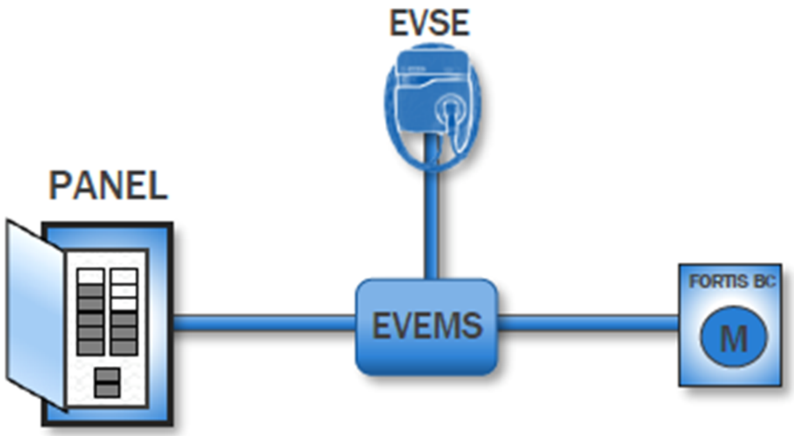
Source: AES. 2019.



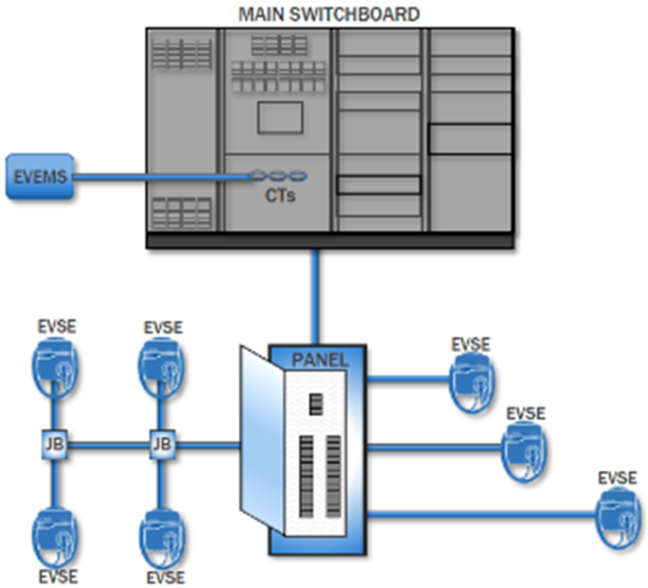
Circuit sharing: Multiple EVSE on a circuit, with control to ensure capacity is not exceeded.



Panel sharing: EVSE loads in excess of panel, with control to ensure capacity is not exceeded.



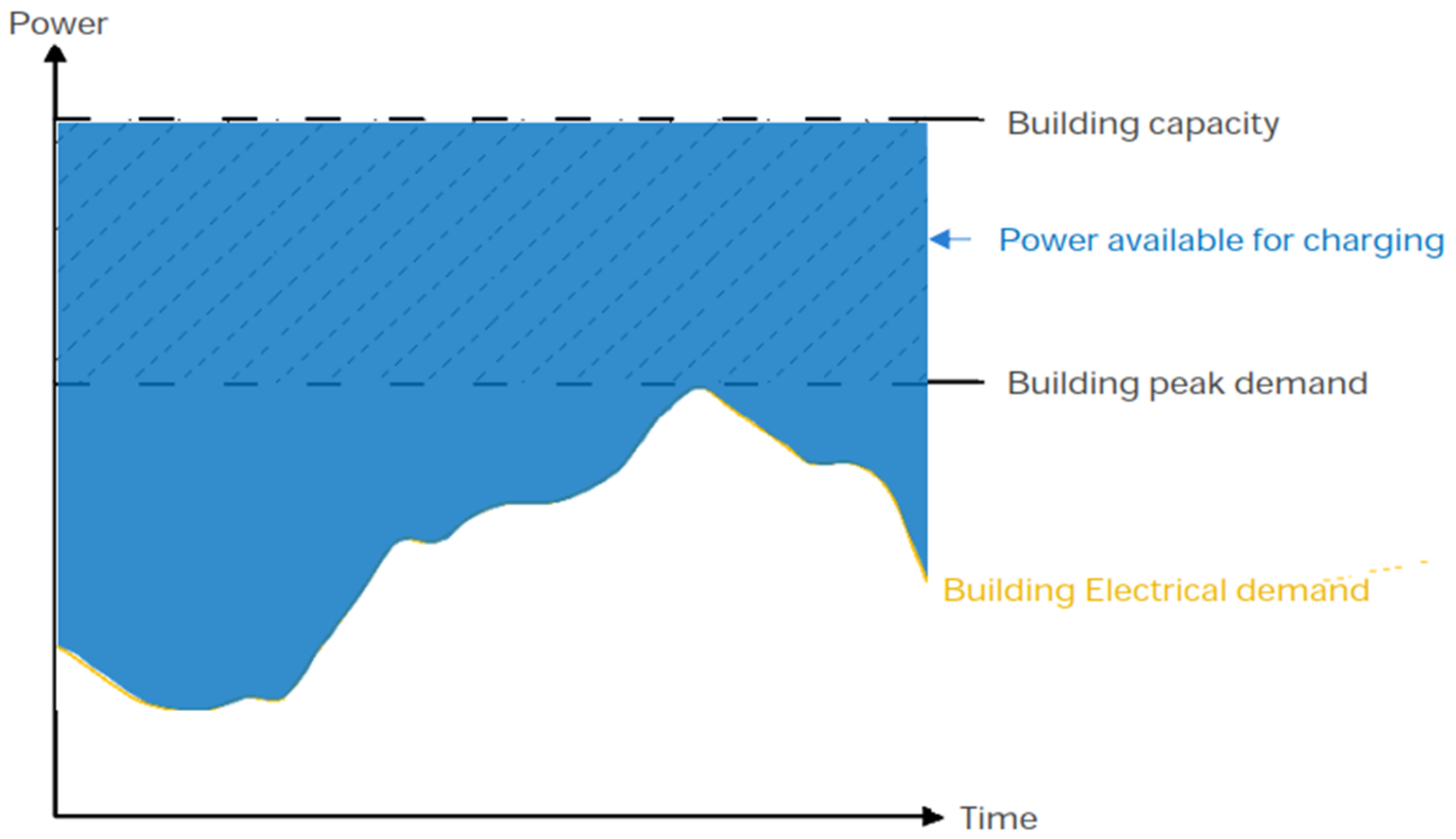
Feeder sharing: on/off control of EVSE based on available capacity on the supply to an electrical panel.



Service monitoring: Monitoring of spare capacity on building's main electrical board; and control of EV loads accordingly.

SERVICE MONITORING EVEMS

- Monitoring the main electrical board of a building to determine available spare capacity in real-time, and control of EVSE accordingly.



Source: AES. Prepared for FortisBC.

FUTURE-PROOFING PARKING TO BE "EV READY"

LOCAL GOVERNMENT REQUIREMENTS

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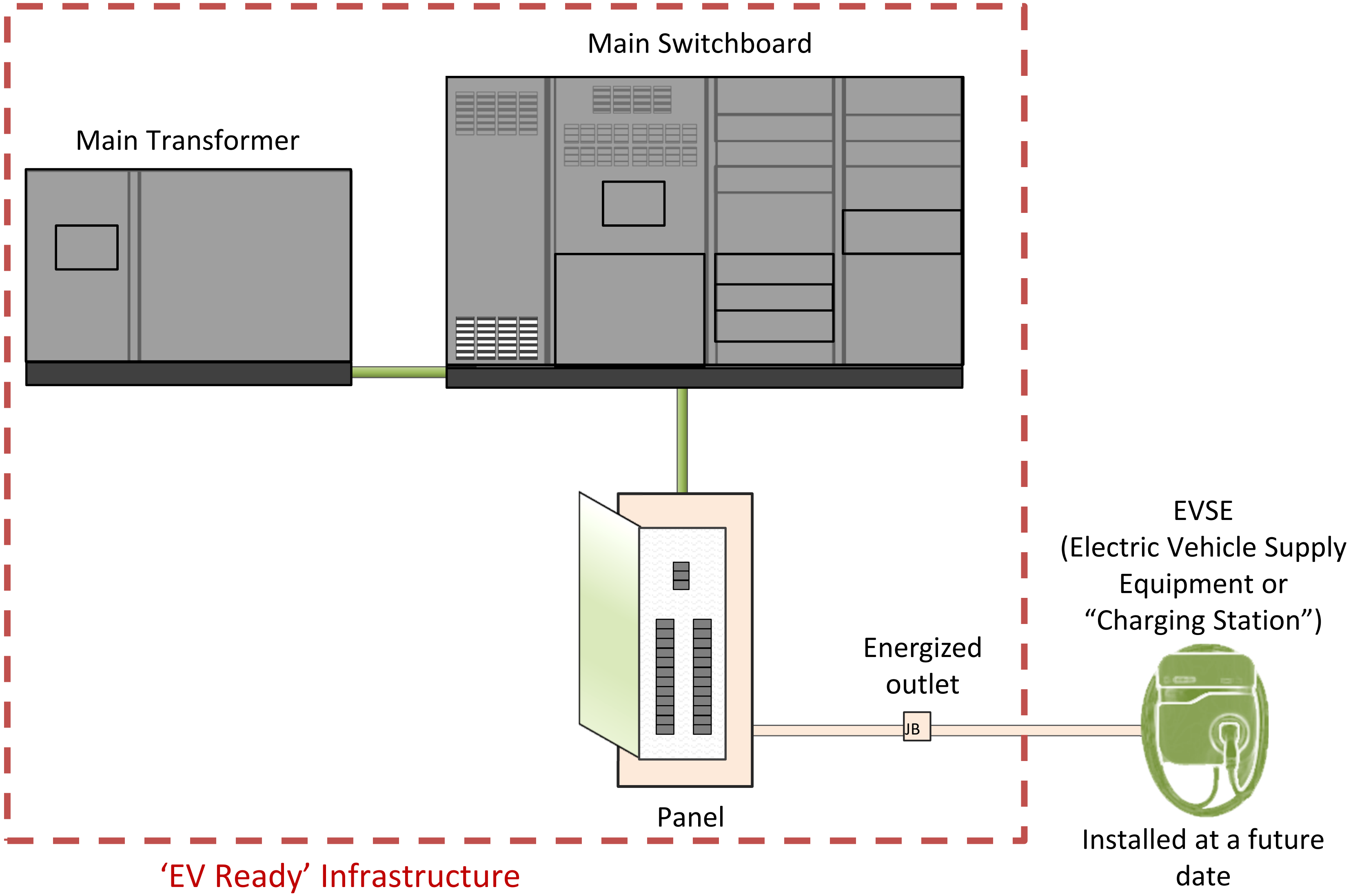
WHAT IS “EV READY” PARKING?



WHAT IS AN “ENERGIZED OUTLET”?

Junction Box

Receptacle

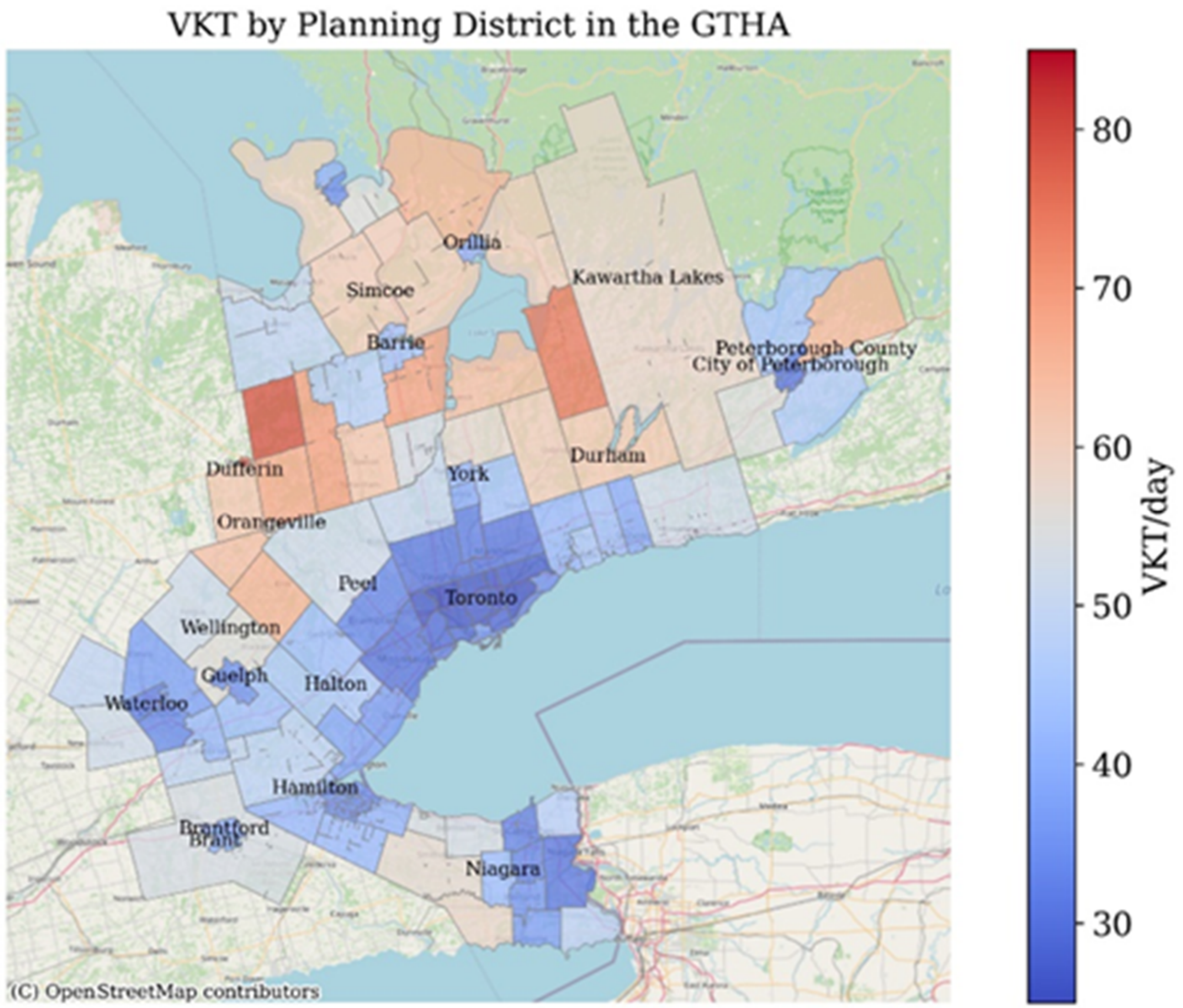
EV READY REQUIREMENTS IN CANADIAN CITIES

Jurisdiction	Residential	Commercial
City of Vancouver	100% EV Ready	10% EV Ready
City of Richmond	100% EV Ready	TBD
City of Port Coquitlam	1 EV Cap. / dwelling	TBD
City of Burnaby	100% EV Ready	TBD
City of Coquitlam	1 EV Ready / dwelling	TBD
City of New Westminster	100% EV Ready	TBD
City of North Vancouver	100% EV Ready	45% EV Ready (In Consultation)
City of Port Moody	100% EV Ready	TBD
District of Squamish	100% EV Ready	TBD
City of Surrey	100% EV Ready	20% EV Ready
Township of Langley	1 EV Ready / dwelling	TBD
District of Saanich	100% EV Ready	Varies
City of Nelson	1 EV Ready / dwelling	10% EV Ready
District of West Van.	100% EV Ready	TBD
City of Victoria	100% EV Ready	5% EV Ready
City of Toronto	20% EV Ready / EVSE 80% Conduit Future – in EV Strategy 100% EV Ready	20% EV Ready / EVSE 80% Conduit / Partial
Previous Ontario Building Code (rescinded)	20% EVSE	20% EVSE

EV CHARGING PERFORMANCE REQUIREMENTS

HOW MUCH POWER DO EVs NEED TO CHARGE?

It (largely) depends on how far they drive…



Data from: Transportation for Tomorrow Survey.
www.transportationtomorrow.on.ca
Special thanks to the University of Toronto Data Management Group!

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HOW MUCH POWER PER VEHICLE IS REQUIRED FOR RESIDENTIAL PARKING IN GTHA?

(ASSUMING ALL PARKING IS MADE EV READY)

- AES modeled appropriate performance requirements
  - Considered:
    - VKT data
    - Average vehicle mix & efficiency
    - Average temperatures
    - Arrival & departure times (conservative)
  - Goal: Ensure enough electricity for next days driving >99% of time, and full charge >90% of time

Compare results to *Toronto Green Standard Version 3's performance requirement*:

"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" – ***e.g. 3-share on 40A circuit***

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

HOW MUCH POWER PER VEHICLE IS REQUIRED FOR RESIDENTIAL PARKING IN GTHA?

(ASSUMING ALL PARKING IS MADE EV READY)

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

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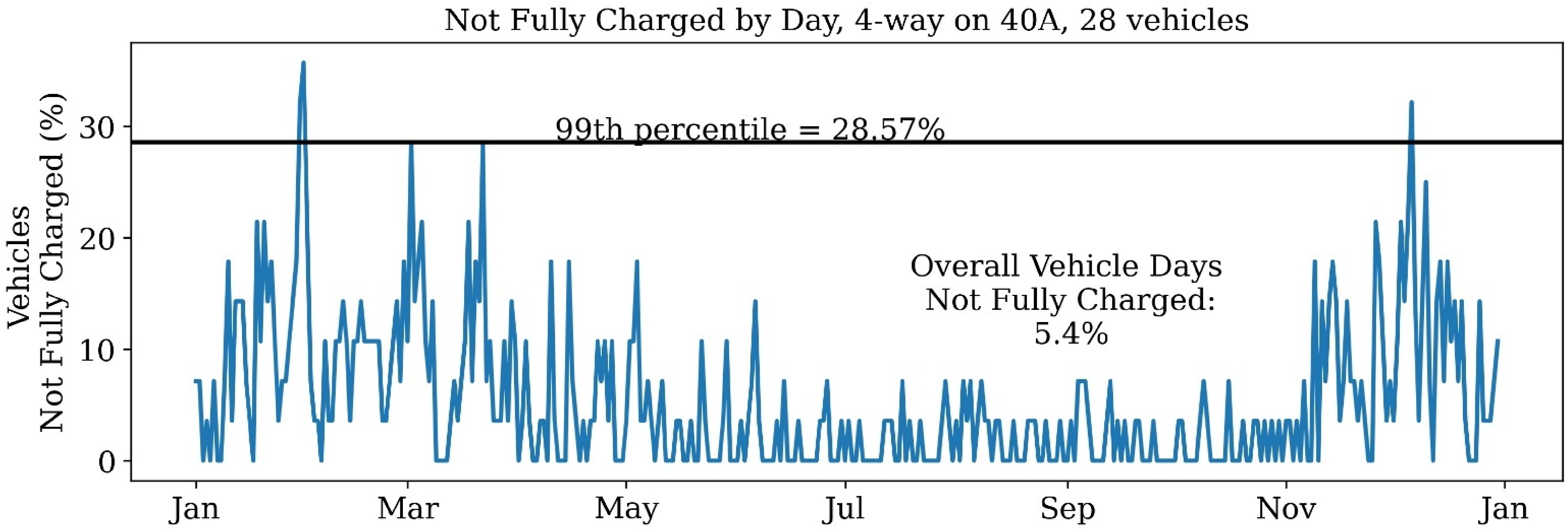
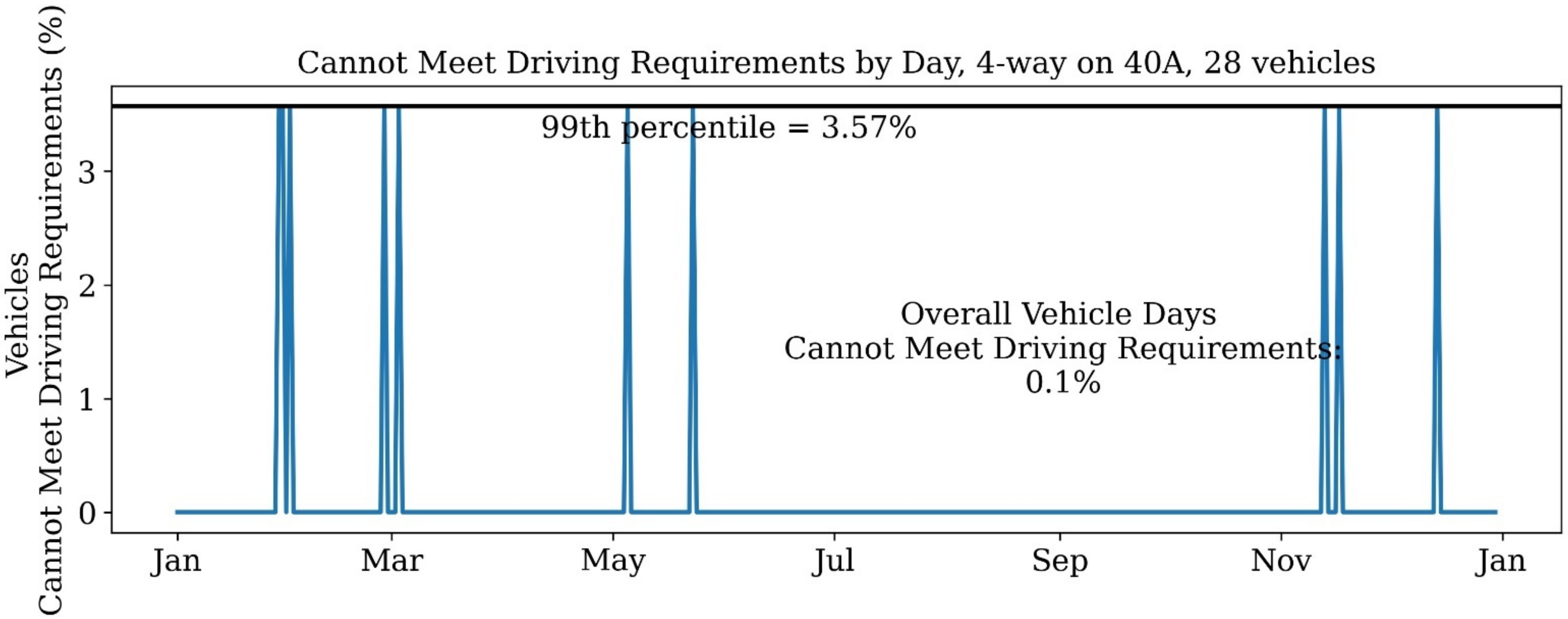
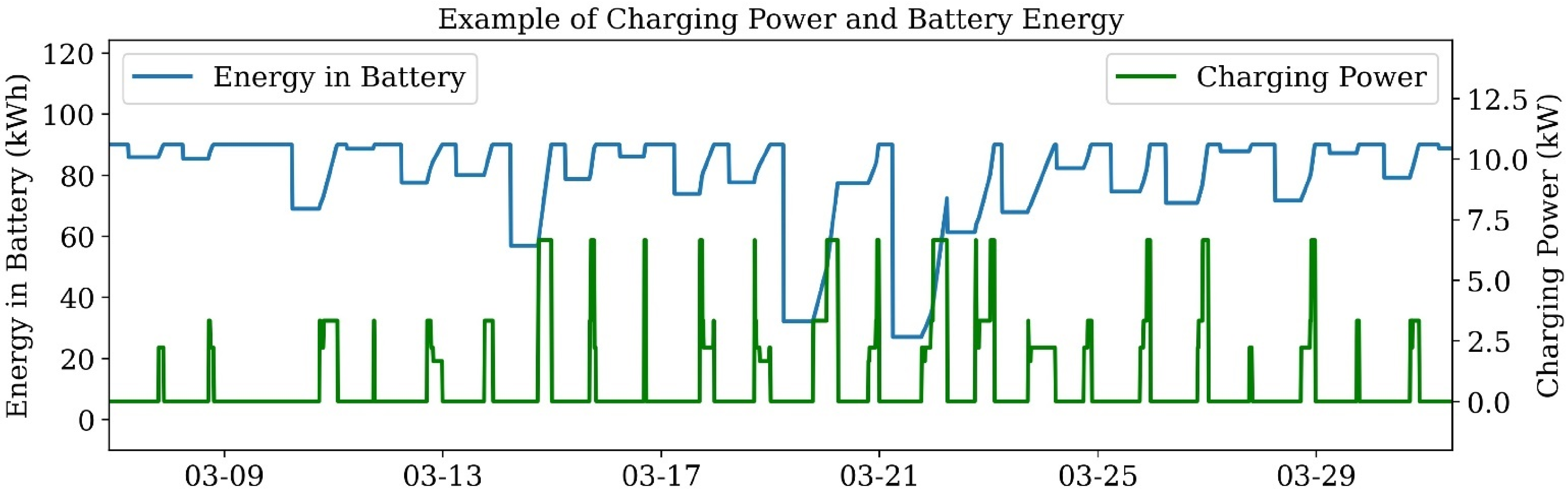
PERCENT OF VEHICLES THAT ARE NOT FULLY CHARGED THROUGHOUT A YEAR OF SIMULATIONS



PERCENT OF VEHICLES THAT CANNOT COMPLETE THE NEXT DAY'S DRIVING THROUGHOUT A YEAR OF SIMULATIONS



CHARGING POWER AND ENERGY IN THE BATTERY OF AN EXAMPLE VEHICLE FOR A FEW SIMULATED WEEKS IN MARCH 2019.



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RECOMMENDED EV CHARGING PERFORMANCE REQUIREMENTS FOR (MOST) GTHA COMMUNITIES

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

COSTING STUDY

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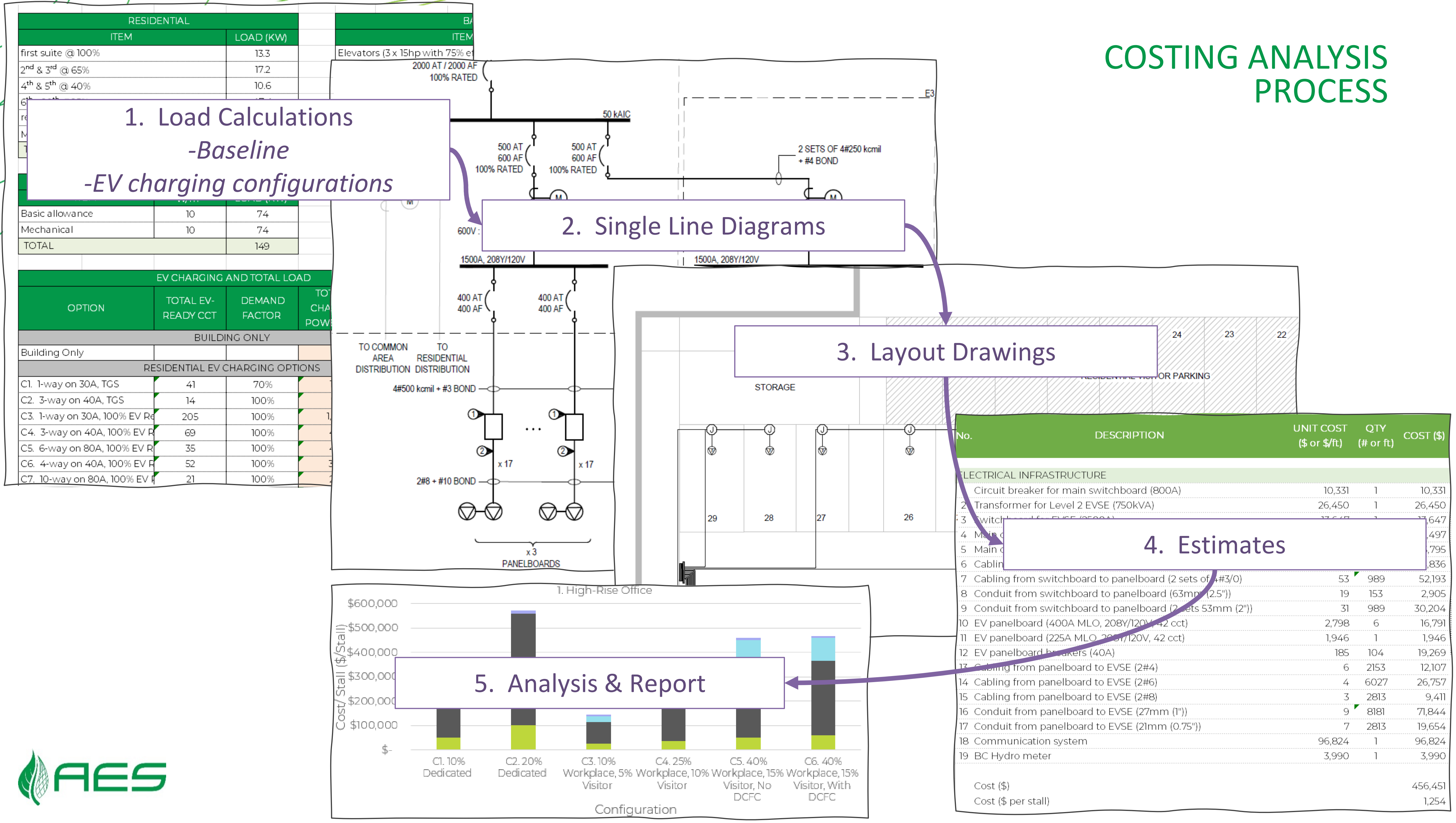
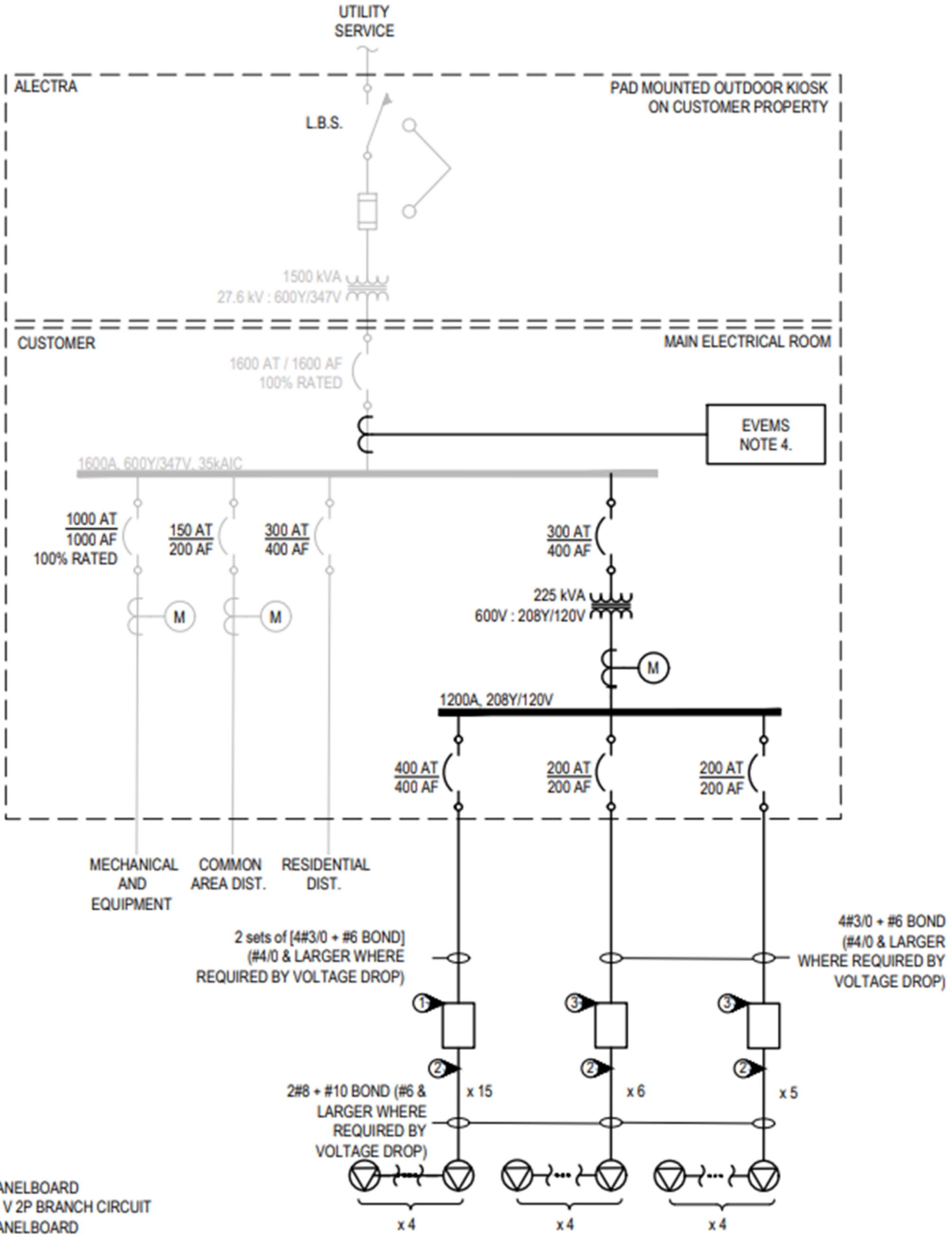
COSTING ANALYSIS PROCESS



EXAMPLE DESIGN – **MID-RISE SCENARIO C7**

4-SHARE ON 40A BRANCH CIRCUITS, WITH SERVICE MONITORING



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

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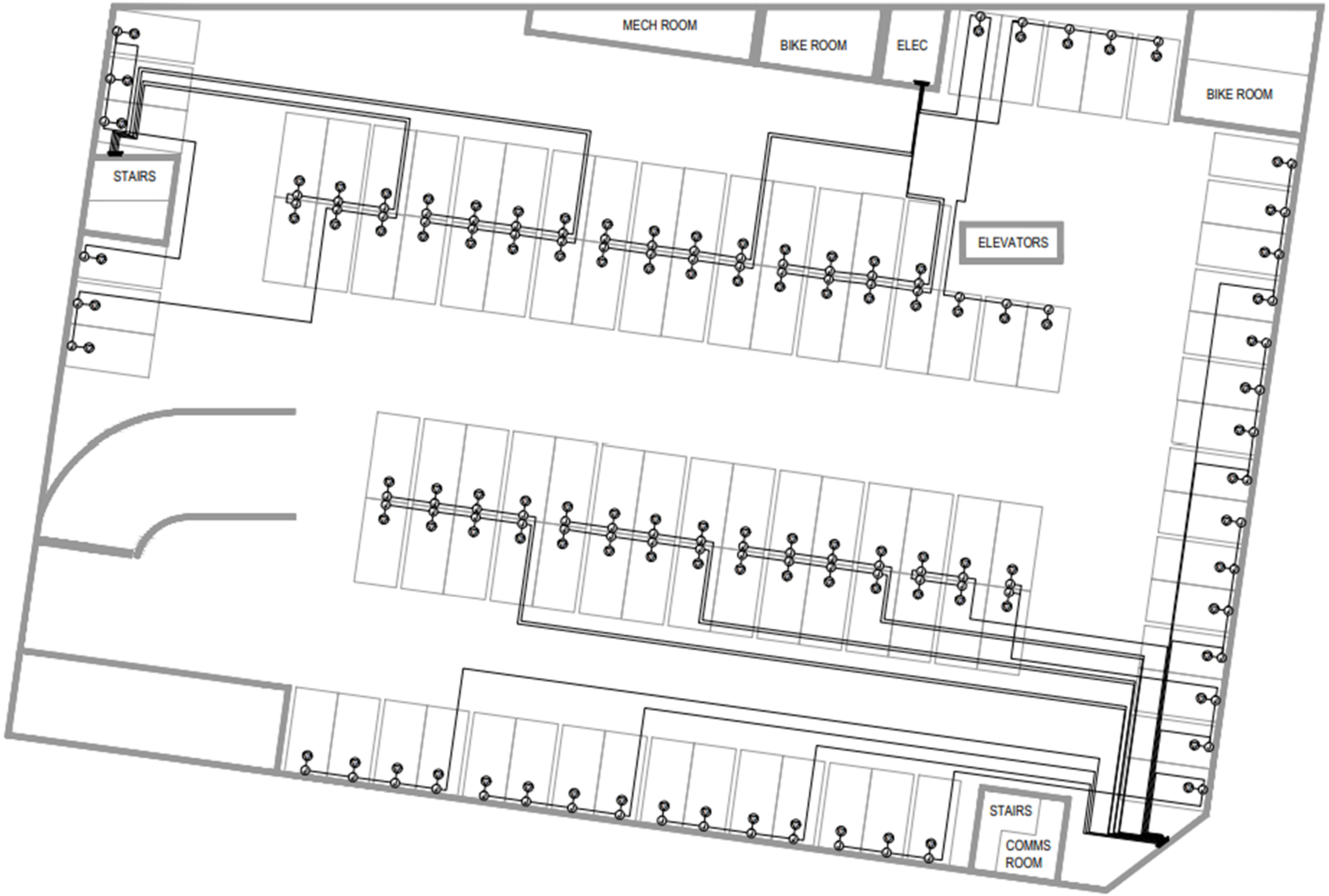
EXAMPLE DESIGN – **MID-RISE SCENARIO C7**

4-SHARE ON 40A BRANCH CIRCUITS, WITH SERVICE MONITORING



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EXAMPLE COSTING – **MID-RISE SCENARIO C7**

4-SHARE ON 40A BRANCH CIRCUITS, WITH SERVICE MONITORING

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)
ELECTRICAL INFRASTRUCTURE				
1	Circuit breaker for EV distribution board (400A)	6,512	1	6,512
2	600V : 208Y/120V, 225 kVA transformer	9,496	1	9,496
3	EV distribution board (1200A)	12,585	1	12,585
4	Circuit breaker for EV panelboard (400A)	6,512	1	6,512
5	Circuit breaker for EV panelboard (200A)	3,809	2	7,619
6	Cabling from switchboard to panelboard (2 sets of 4#3/0)	60	669	40,489
7	Conduit from EV switchboard to panelboard (2 sets of 53mm (2"))	35	669	23,429
8	EV panelboard breaker (40A)	232	30	6,946
9	400A MLO, 208Y/120V, 42 cct panelboard	3,121	2	6,242
10	225A MLO, 208Y/120V, 42 cct panelboard	2,184	2	4,368
11	Cabling from panelboard to EVSE (2#8)	4	2992	12,407
12	Conduit from panelboard to EVSE (21mm (3/4"))	9	2992	25,983
13	Communication system	27,664	1	27,664
14	Utility meter	3,990	1	3,990
	Cost ($)			194,241
	Cost ($ per stall)			1,868

EXAMPLE COSTING – **MID-RISE SCENARIO C7**

4-SHARE ON 40A BRANCH CIRCUITS, WITH SERVICE MONITORING

No.	DESCRIPTION	UNIT COST ($ or $/ft)	QTY (# or ft)	COST ($)	MULTIPLIER FOR LATER COSTS	LATER COST ($)
ELECTRICAL INFRASTRUCTURE						
1	Circuit breaker for EV distribution board (400A)	6,512	1	6,512	3	19,535
2	600V : 208Y/120V, 225 kVA transformer	9,496	1	9,496	3	28,487
3	EV distribution board (1200A)	12,585	1	12,585	5	62,923
4	Circuit breaker for EV panelboard (400A)	6,512	1	6,512	3	19,535
5	Circuit breaker for EV panelboard (200A)	3,809	2	7,619	3	22,857
6	Cabling from switchboard to panelboard (2 sets of 4#3/0)	60	669	40,489	2	80,979
7	Conduit from EV switchboard to panelboard (2 sets of 53mm (2"))	35	669	23,429	5	117,145
8	EV panelboard breaker (40A)	232	30	6,946	2	13,892
9	400A MLO, 208Y/120V, 42 cct panelboard	3,121	2	6,242	3	18,725
10	225A MLO, 208Y/120V, 42 cct panelboard	2,184	2	4,368	3	13,103
11	Cabling from panelboard to EVSE (2#8)	4	2992	12,407	2	24,814
12	Conduit from panelboard to EVSE (21mm (3/4"))	9	2992	25,983	5	129,915
13	Communication system	27,664	1	27,664	3	82,992
14	Utility meter	3,990	1	3,990	2	7,980
	Cost ($)			194,241		642,883
	Cost ($ per stall)			1,868		6,182

RESIDENTIAL BUILDING ARCHETYPES

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

#	Electrical configuration description	% Residential Parking that is EV Ready	Nominal EVSE Power (kW)	EVSE per Circuit	Circuit Breaker Rating (A)
C1	**TGS v3 - Dedicated 40A circuit**	20%	6.7	1	40
C2	**TGS v3 - 3-share on 40A**	20%	6.7	3	40
C3	**Dedicated 40A circuit**	100%	6.7	1	40
C4	**3-share on 40A**	100%	6.7	2	40
C5	**4-share on 40A**	100%	6.7	4	40
C6	**10-share on 80A**	100%	6.7	3	80
C7	**4-share on 40A, service monitoring**	100%	6.7	4	40

For all High Rise scenarios, we considered locating the building in both Toronto Hydro and Alectra utility territory, reflecting different primary distribution voltages.

MID RISE SCENARIOS

#	Electrical configuration description	% Residential Parking that is EV Ready	Nominal EVSE Power (kW)	EVSE per Circuit	Circuit Breaker Rating (A)
C1	**TGS v3, Dedicated 40A circuit**	20%	6.7	1	40
C2	**TGS v3, 3-share on 40A**	20%	6.7	3	40
C3	**Dedicated 40A circuit**	100%	6.7	1	40
C4	**3-share on 40A**	100%	6.7	2	40
C5	**4-share on 40A**	100%	6.7	4	40
C6	**10-share on 80A**	100%	6.7	3	80
C7	**4-share on 40A, service monitoring**	100%	6.7	4	40

TOWNHOUSE SCENARIOS

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

SINGLE FAMILY SUBDIVISION SCENARIOS

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

RESULTS

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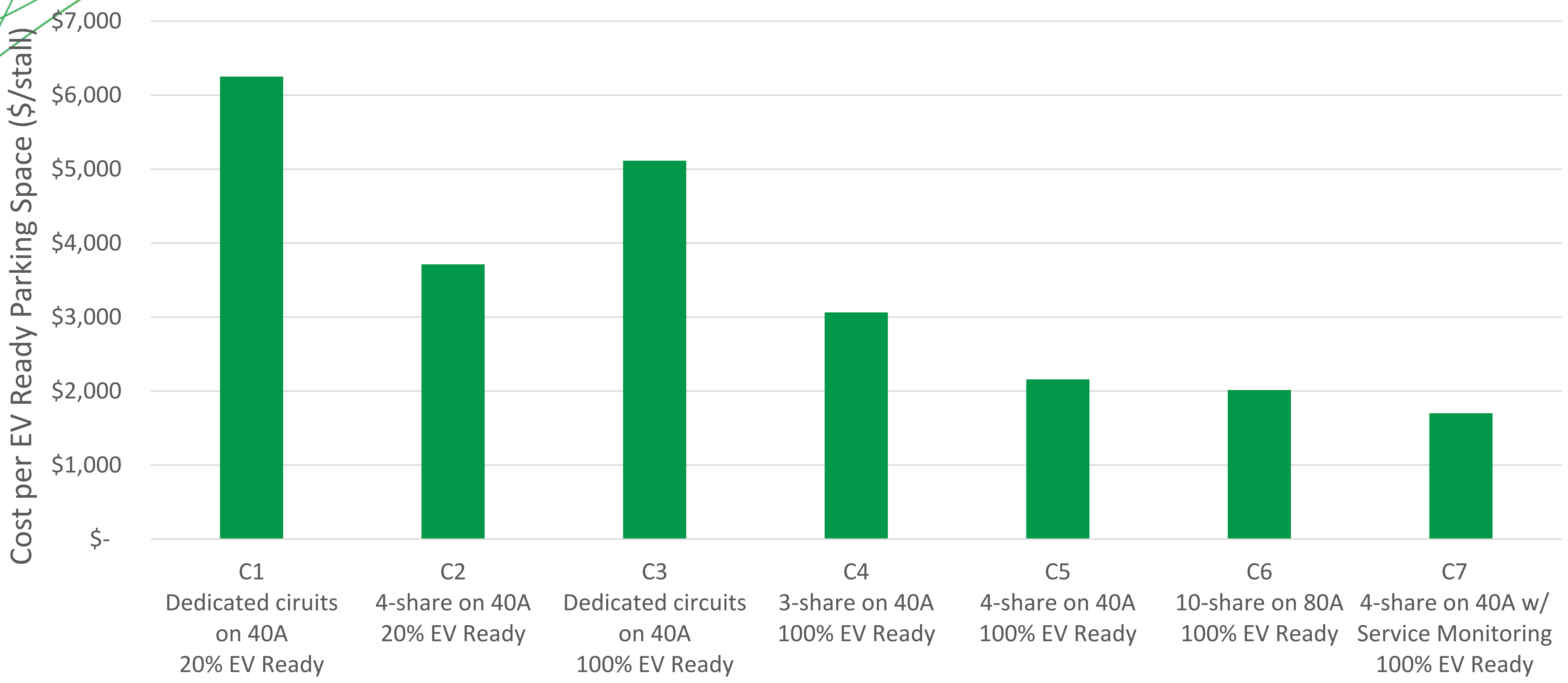
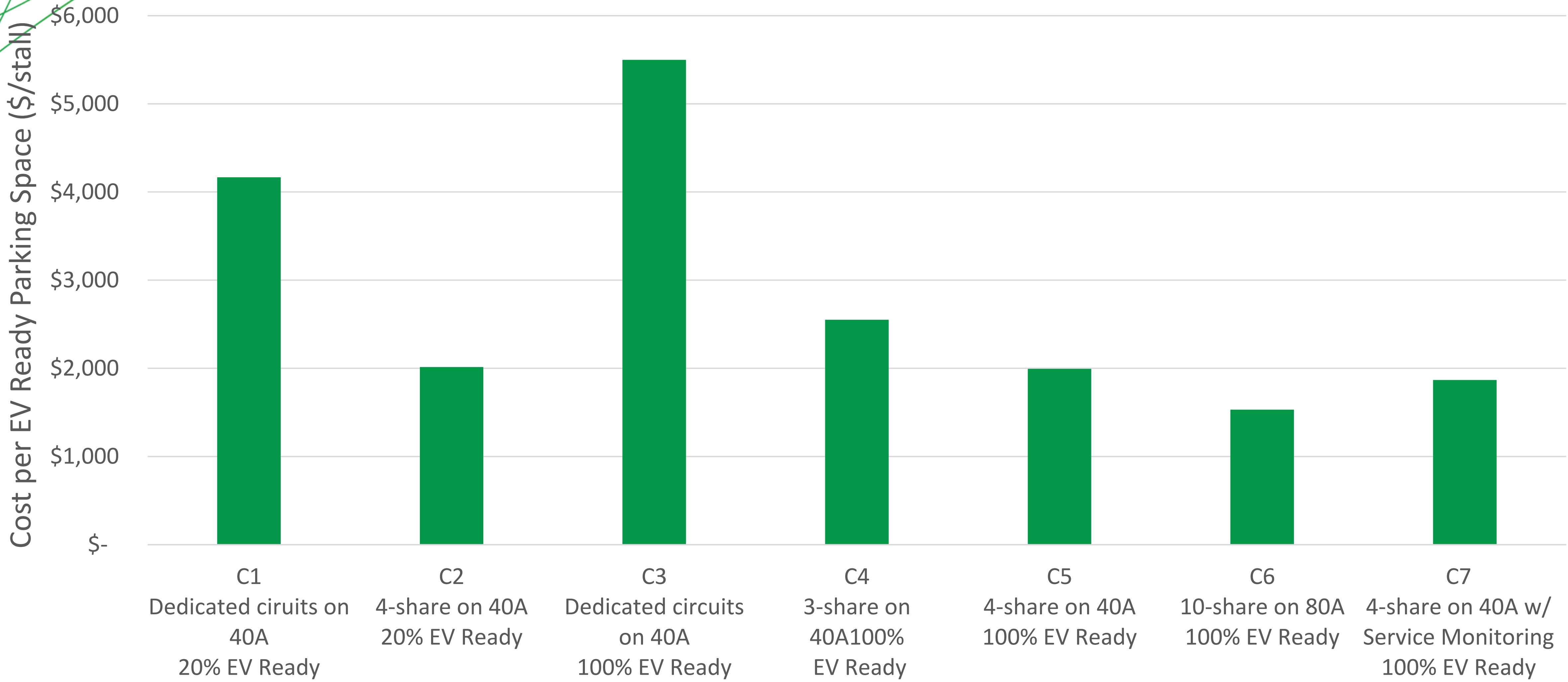
RESULTS
HIGH RISE (ALECTRA TERRITORY)



RESULTS
MID RISE



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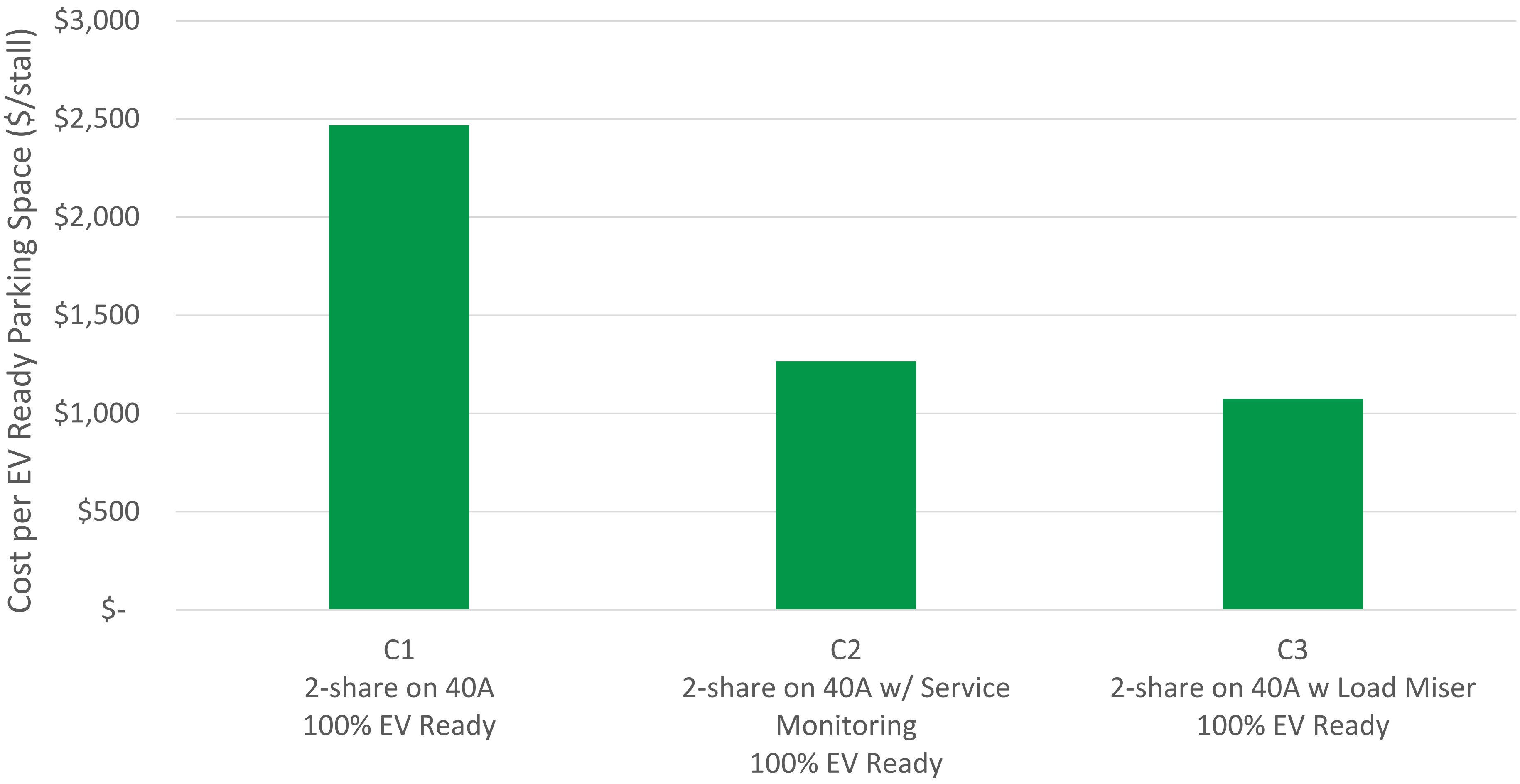
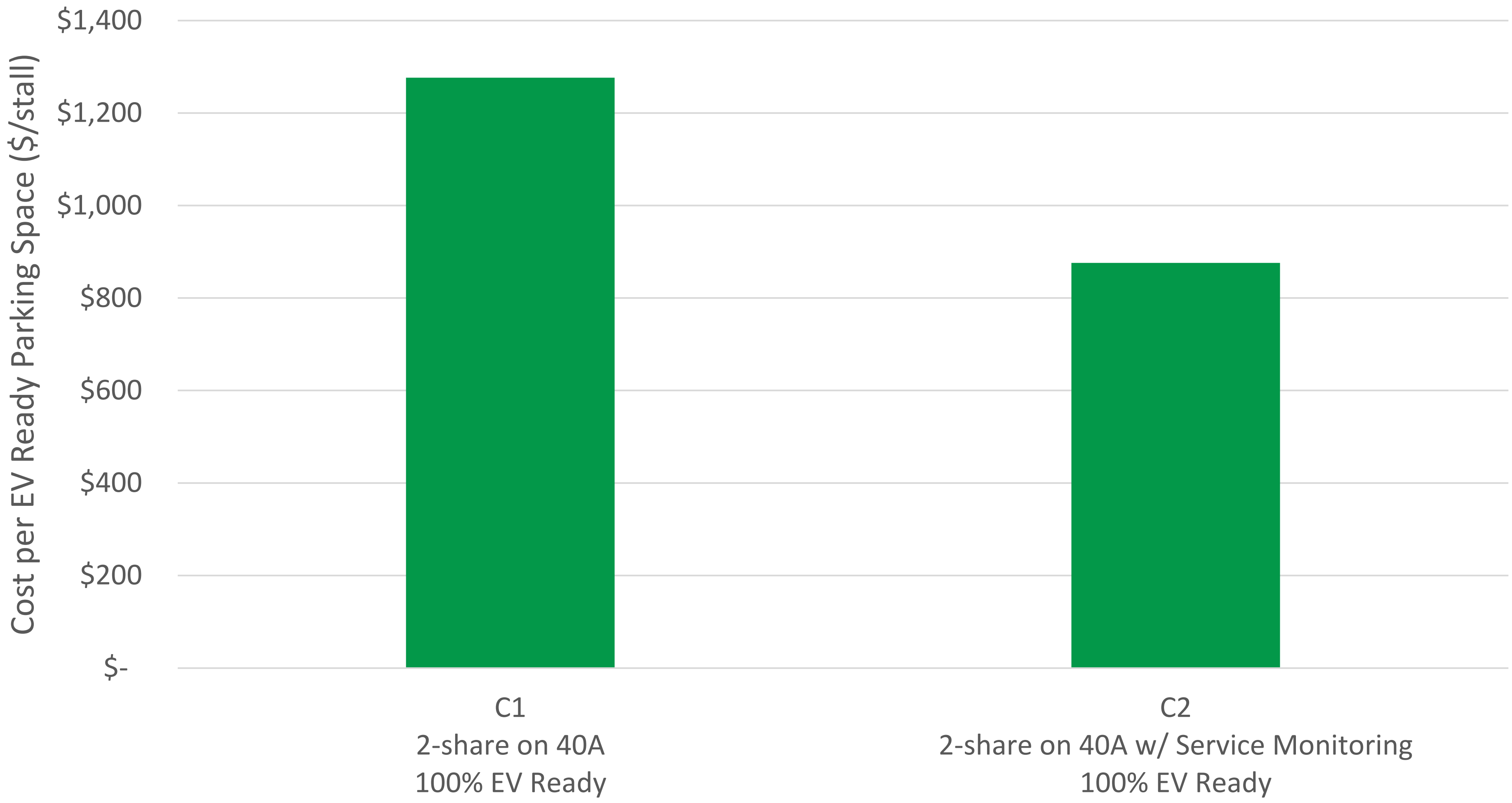
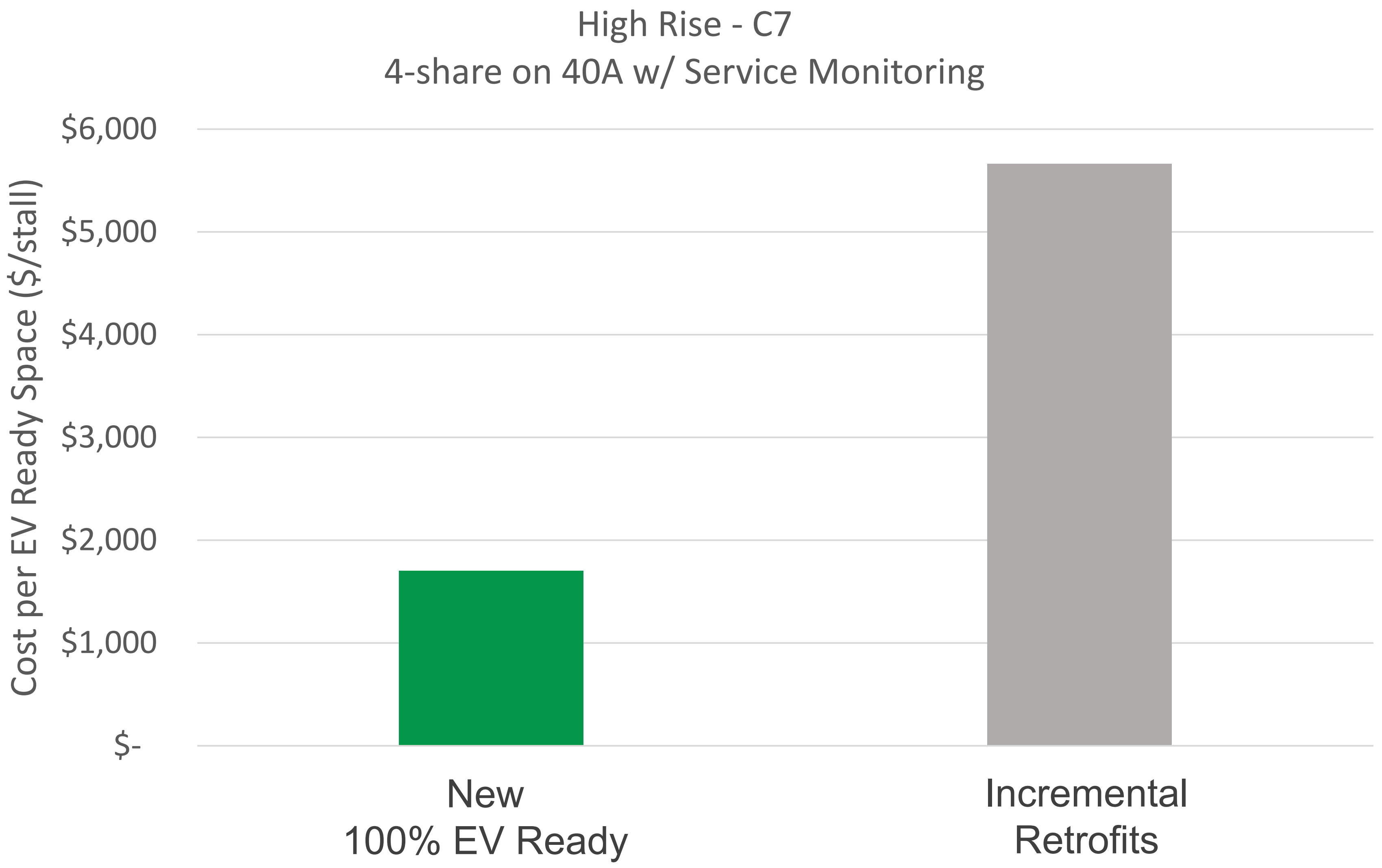
RESULTS
TOWNHOUSE



RESULTS
SINGLE FAMILY SUBDIVISION



COST OF EV READY NEW CONSTRUCTION VERSUS INCREMENTAL RETROFITS
Example – High Rise



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THANK YOU!

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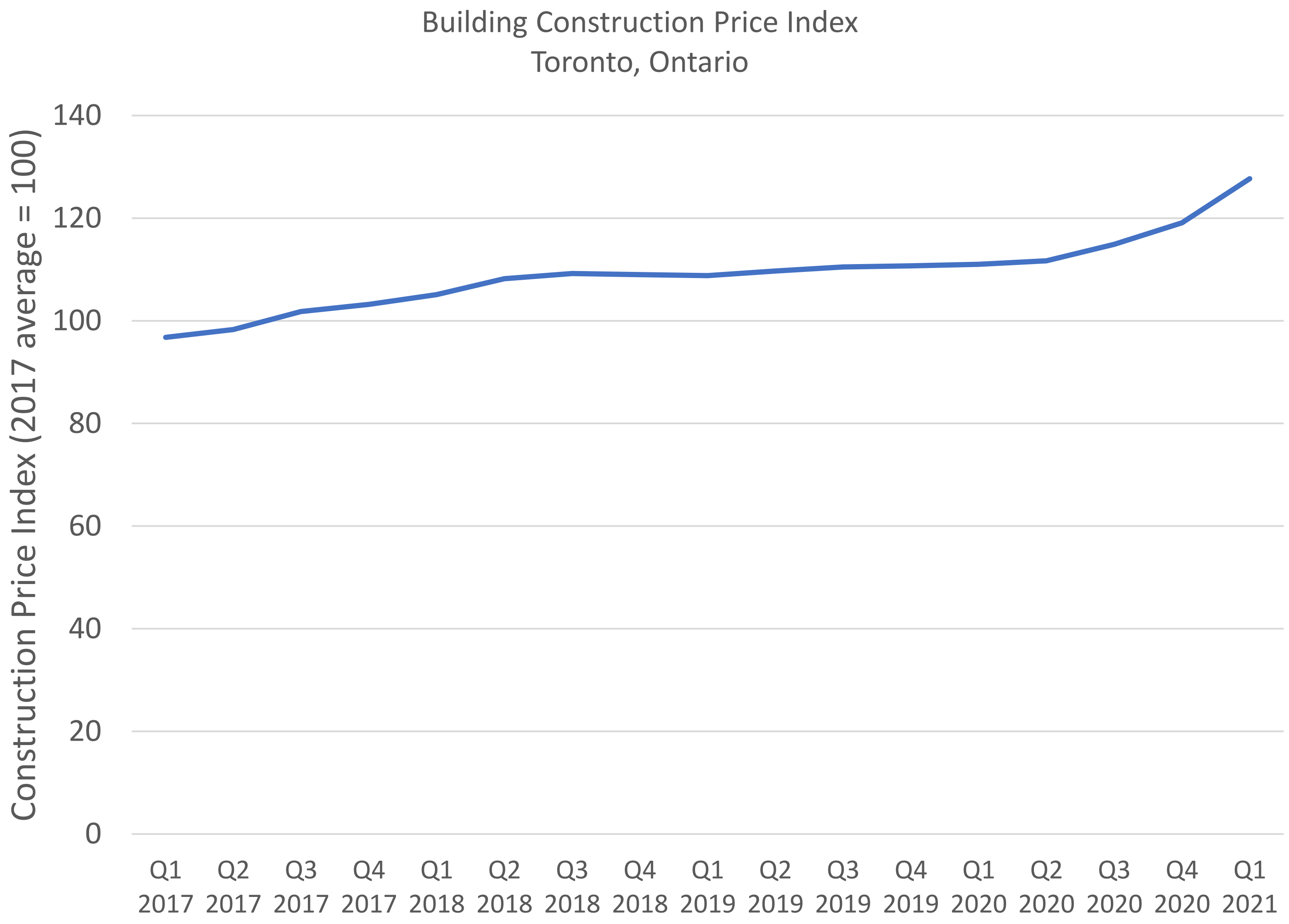
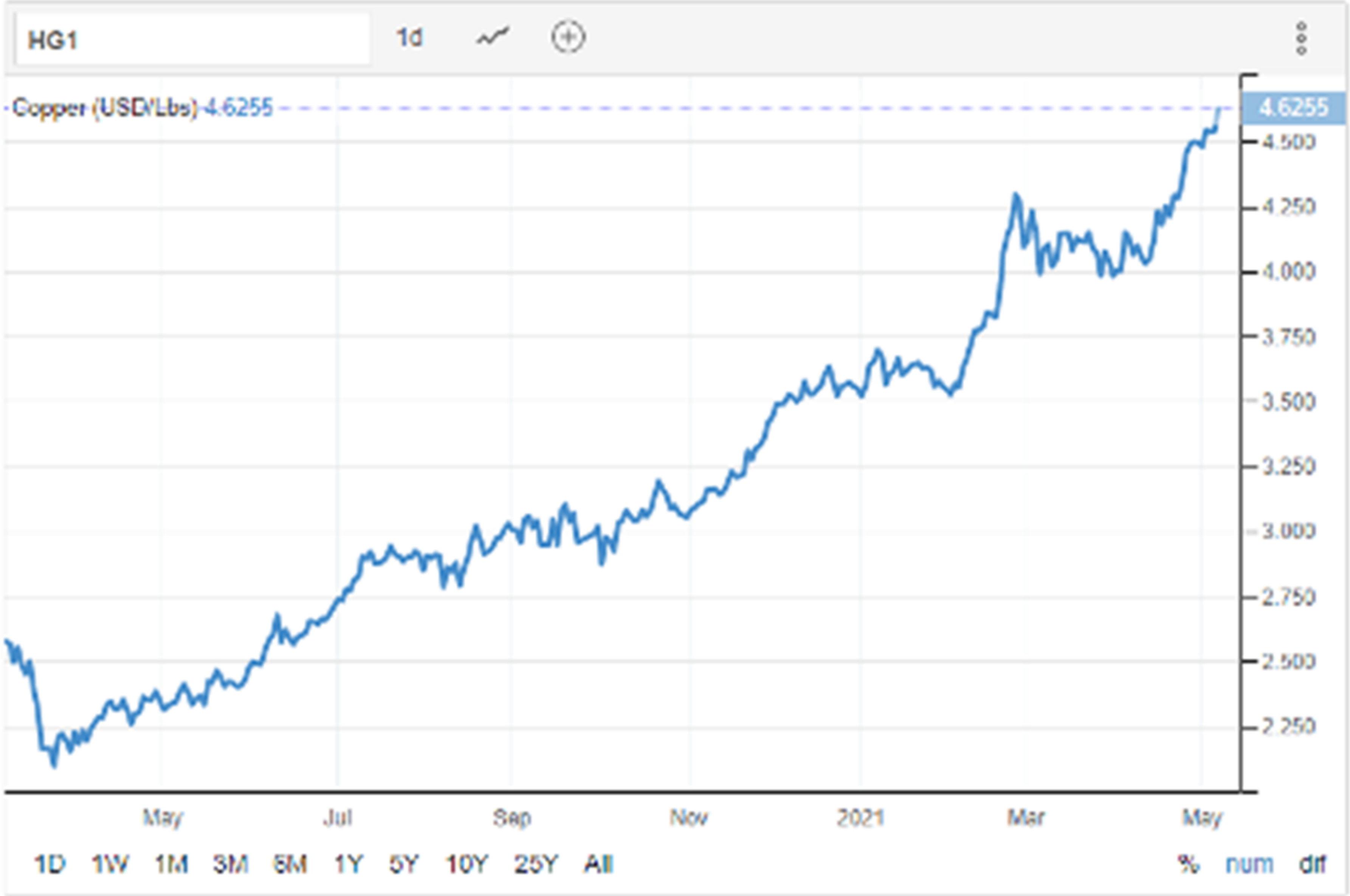
OTHER CONSIDERATIONS

CONSTRUCTION COSTS



Source: Stats Canada.

COSTS OF COPPER 2020-2021



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DEVELOPMENTS' CAPITAL CONTRIBUTION FOR UTILITY EXTENSIONS

- Developments' "capital contribution" is difference between the present value of the utility 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).
- Utilities evaluate revenue forecast (i.e. estimated average kWh and kW charges) for future customers (*Distribution System Code* 3.2.20 & Appendix B).
  - For expansions that require a capital contribution, expansion deposit for the present value of the forecasted revenues (*Distribution System Code* 3.2.20).
  - 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) each year for five years (*Distribution System Code* 3.2.23) [21].
  - **Recommended that utilities consider utility policies that accurately reflect how EV charging is likely to emerge over 5 years.**
- Cost of increasing utility services differs substantially between different development sites.
  - **Service monitoring can avoid service size upgrades.**

LOAD MONITORING & LOAD SWITCHING CONTROLS

Smart Circuit Splitters (EV Charging and Appliances)

There are a few types of smart circuit splitters shown in the table below. Smart circuit breakers allow two devices (typically high power) to share a circuit, which can avoid an electrical panel upgrade (For example, like an EV charger and a Dryer). A more sophisticated version of this (DCC and EVduty) will actually monitor the whole home's power consumption then adjust EV charging accordingly. The Neo Charge and the Dryer Buddy both come with built in plugs for attaching to the wall and two appliances, so they are easy to install. Both products also have two options for power sharing – the first, power is supplied to one device or another, and the second, power is supplied to two devices simultaneously. The SimpleSwitch is typically hardwired and just has the first option of powering one device at a time. The Thermolec DCC products and the Evduty will both monitor a whole homes power consumption – however the DCC products will turn EV charging off when the load on the home panel exceeds 80% of its rated capacity, versus the Evduty that will determine the left-over power space on the panel, then supply this to the EV for continuous charging.

	Neo Charge[116] Smart Splitter 	**BSA Electronics**[117] Dryer Buddy 	**SimpleSwitch**[118] 240V Circuit Switch 	**Splitvolt**[119] Splitter Switch 	**Thermolec**[120] DCC 	**Evduty**[121] Smart Current Sensor 
Cost ($)	$500 (Appliance) $550 (Dual Car)	$200 – 365 (several outlet versions)	$550 (240V) $650 (EV) $550 (120V)	$319	$1,050 (DCC-9), $945 (DCC-10)	$500
Switch On/Off Between Two Devices	Yes	Yes	Yes	Yes	NA	NA
Continuous Power to Two Devices	Yes	Yes	No	No	NA	Yes, *shares power between appliance circuit and EV circuit*
Monitors Whole House Loads	No	No	No	No	Yes, *if total panel exceeds 80% rated load, turns off EV charging. Reconnects automatically*	Yes, *monitors a unit/home's current draw, left over current will be used to charge EV*
NEMA Outlet *(NEMA-Amps)*	*10-30, 14-30, 14-50, (10-50 for portable))*	*10-30 to 10-30, 10-30 to 14-50, 14-30 to 14-30)*	Hardwired, Optional Plugin	*10-30, 14-30, 14-50*	Hardwired	Hardwired, or NEMA 6-50, 14-50 outlet
Additional Notes		digital display that shows the draw of each load.	120V version as well	Full color display screen	Multifamily and Single Family, DCC-10 uses one double pole breaker slot	Multifamily and Single Family.