# Greater Toronto Hamilton Area EV Ready Residential Parking

## New Construction Costing Study

Prepared for the Clean Air Partnership

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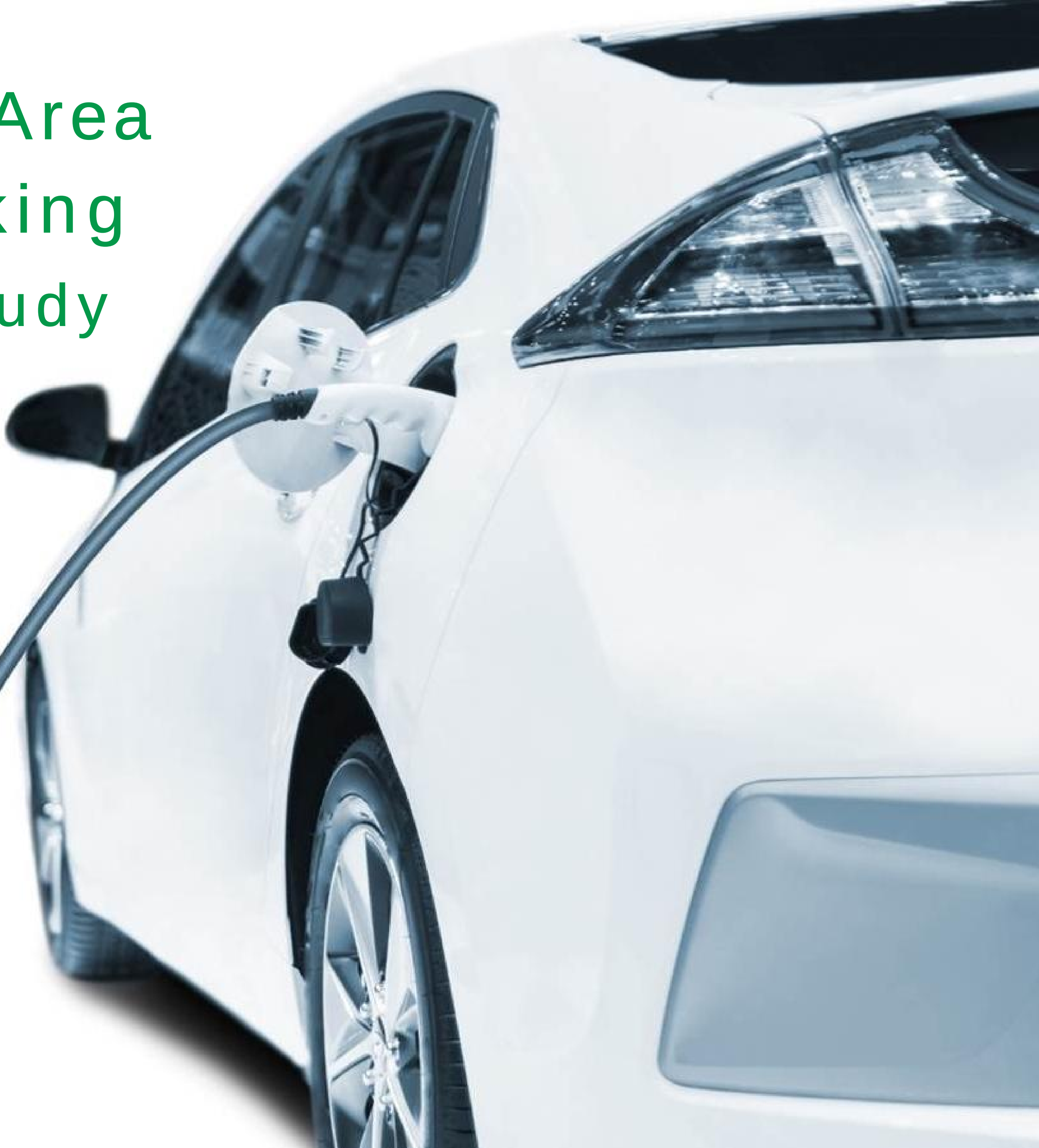
AES Engineering



# 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

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# EV TRENDS & CONTEXT

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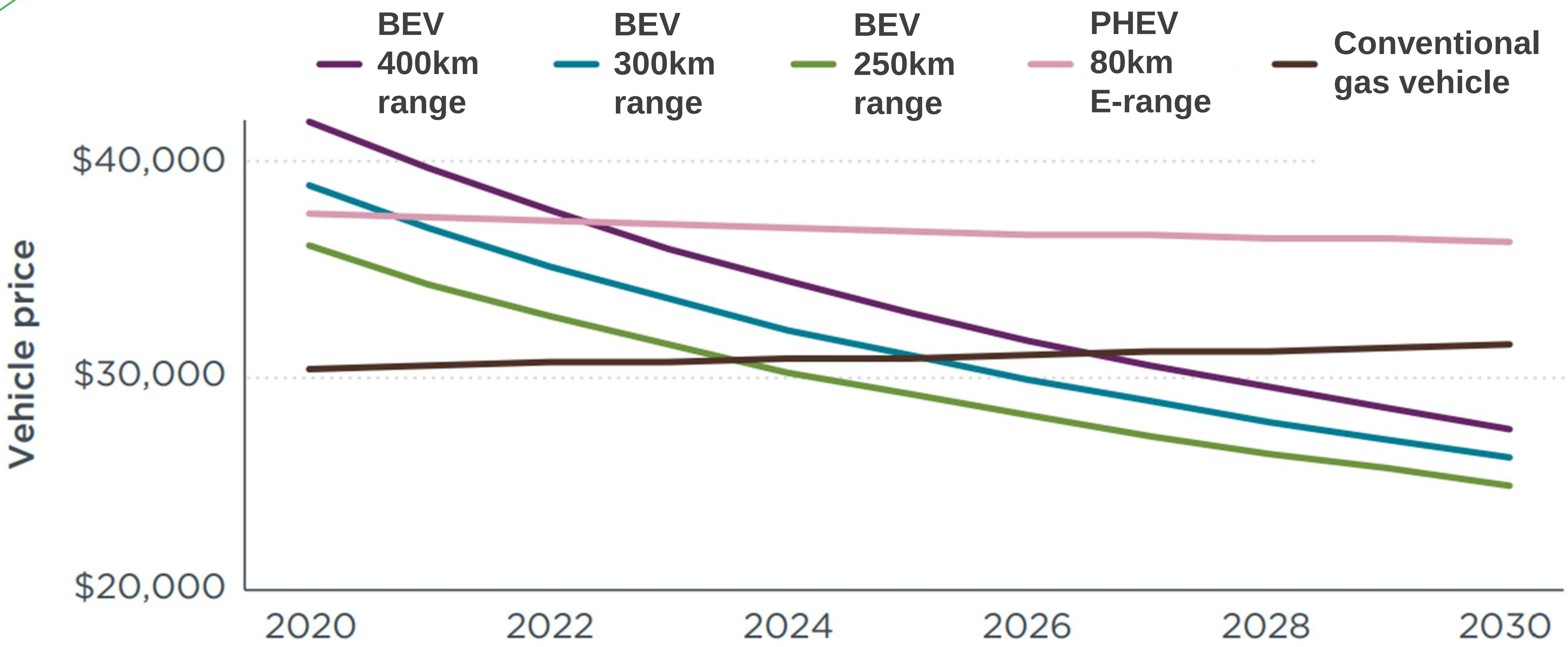
# EV “PRICE PARITY” (NO INCENTIVES)




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

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# POLICY IS DRIVING EV ADOPTION

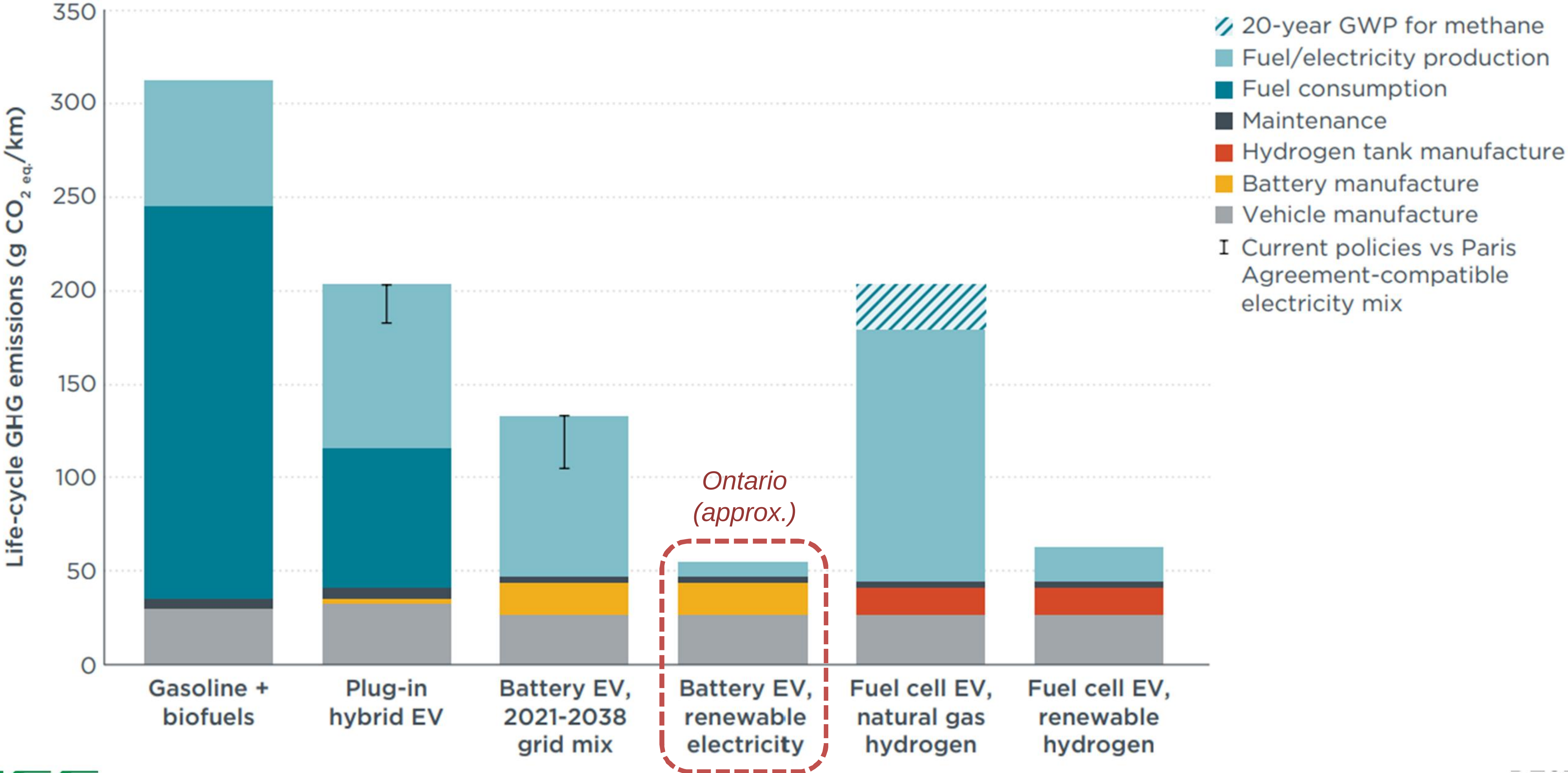
- In June 2021, the Federal Government announced it would adopt **requirements for 100% of passenger vehicle sales to be zero emissions (e.g. EVs) by 2035.**

**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

# 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)]

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# 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.

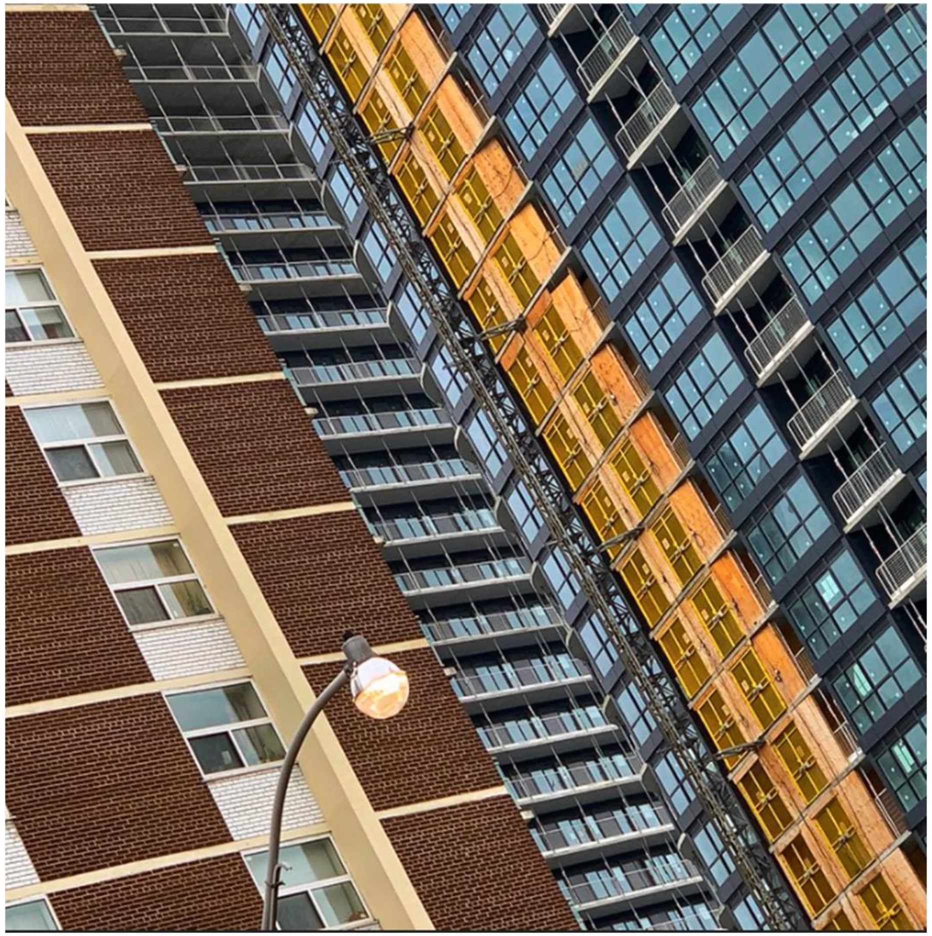

Image Credit: Timothy Neesam.

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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.

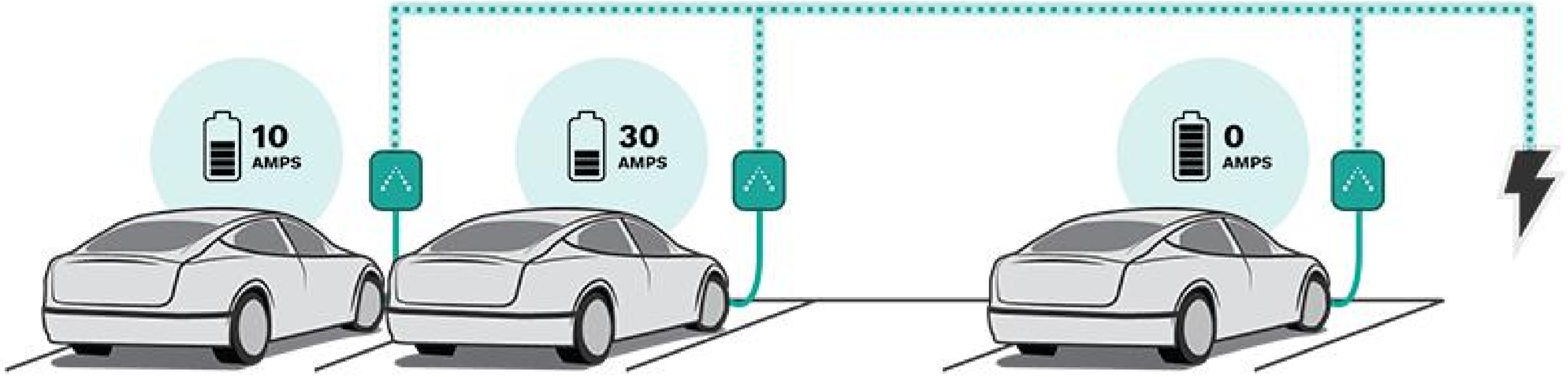
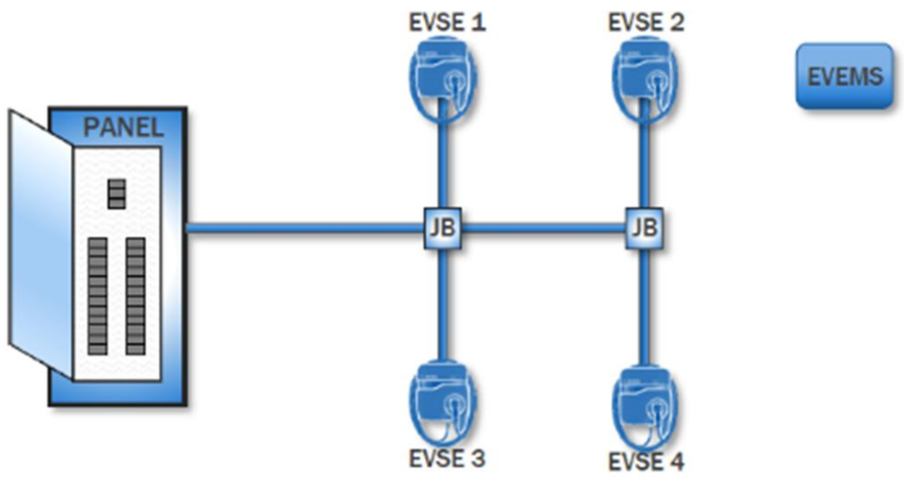


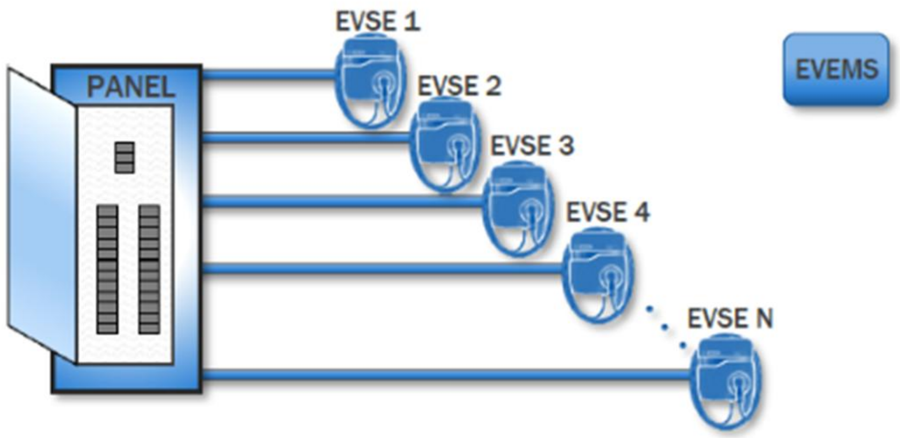

Image Source: Evercharge.

# Some Electrical Infrastructure Configurations

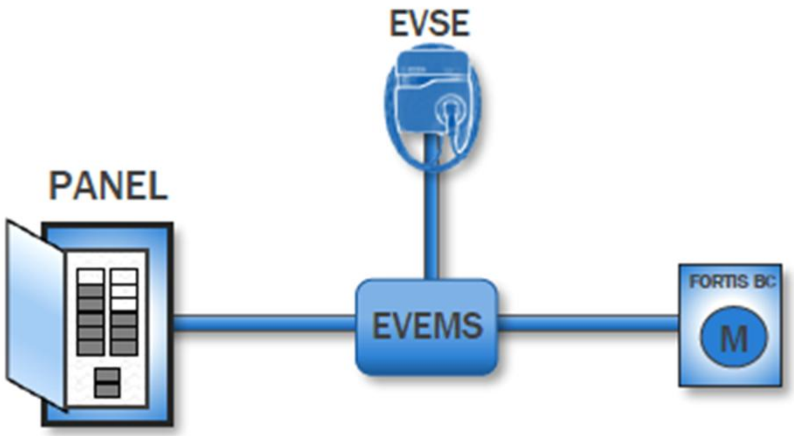
**Source:** AES. 2019.



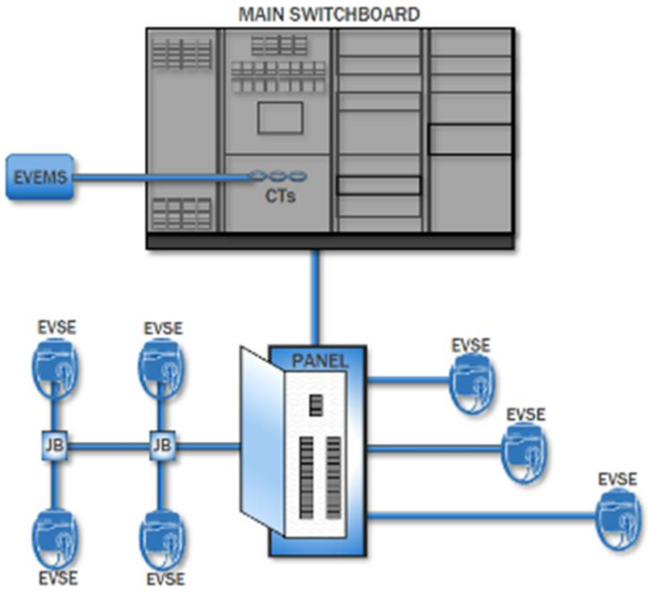

**Circuit sharing:** Multiple EVSE on a circuit, with control to ensure capacity is not exceeded.




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

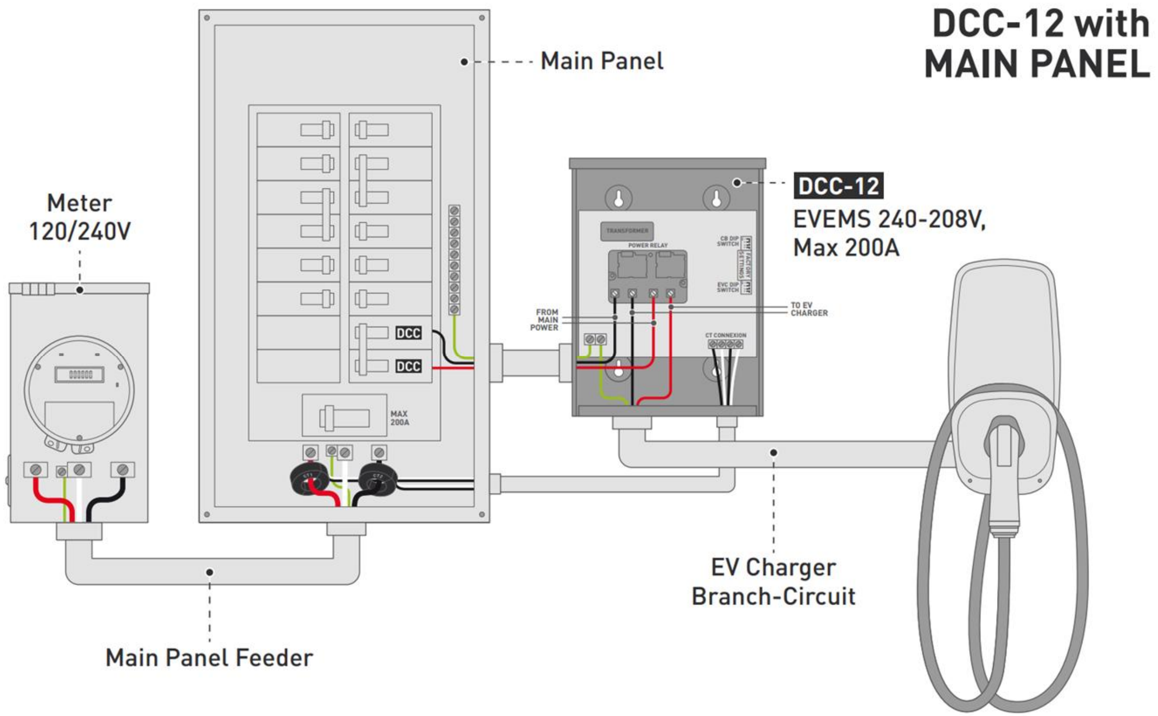



**Feeder sharing:** on/off control of EVSE based on available capacity on the supply to an electrical panel.

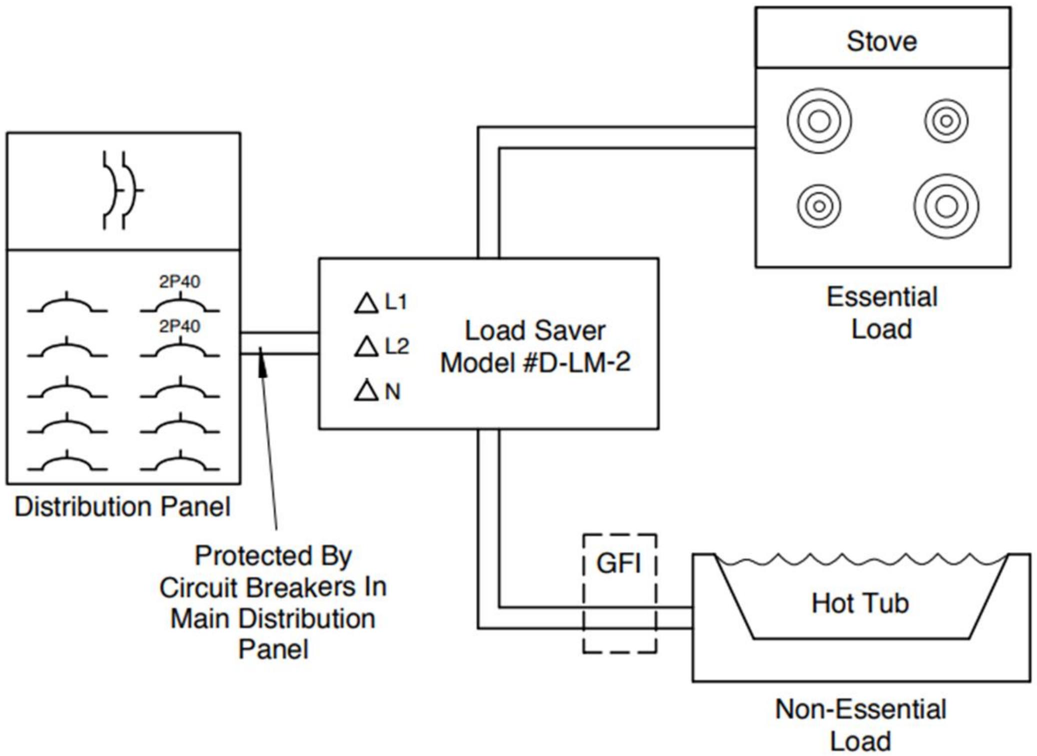



**Service monitoring:** Monitoring of spare capacity on building's main electrical board; and control of EV loads accordingly.

# Example EVEMS for Single Family Homes & Townhome Applications




Source: RVE.




Source: AC Dandy.

# FUTURE-PROOFING PARKING TO BE “EV READY”

## LOCAL GOVERNMENT REQUIREMENTS

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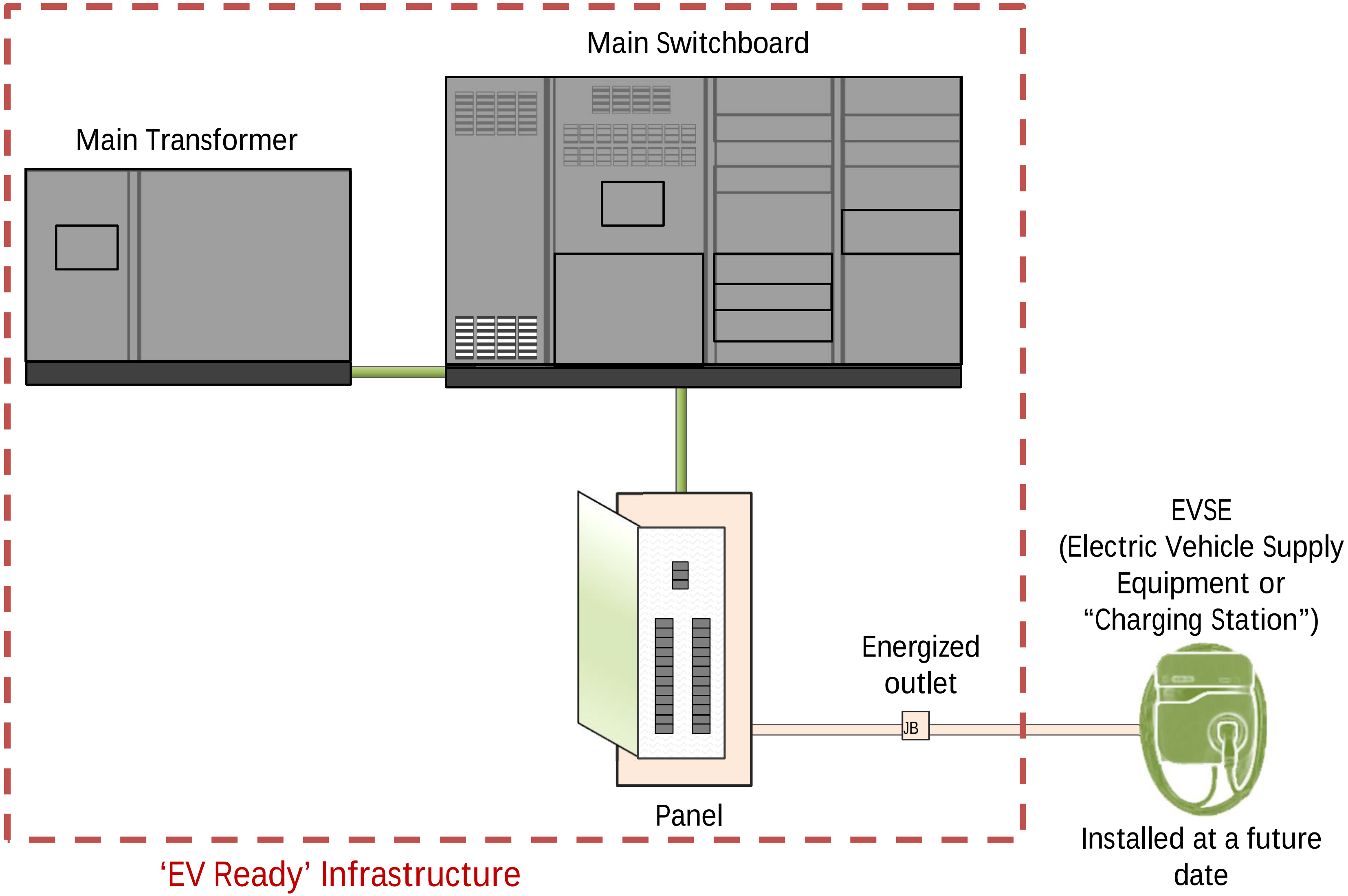
# WHAT IS "EV READY" PARKING?

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# WHAT IS AN "ENERGIZED OUTLET"?

Junction Box

Receptacle

# EV READY REQUIREMENTS IN CANADIAN CITIES

| Jurisdiction | Residential | Commercial |
|---|---|---|
| City of Vancouver, BC | 100% EV Ready | 10% EV Ready |
| City of Richmond, BC | 100% EV Ready | TBD |
| City of Port Coquitlam, BC | 1 EV Cap. / dwelling | TBD |
| City of Burnaby, BC | 100% EV Ready | TBD |
| City of Coquitlam, BC | 1 EV Ready / dwelling | TBD |
| City of New Westminster, BC | 100% EV Ready | TBD |
| City of North Vancouver, BC | 100% EV Ready | 45% EV Ready<br>(In Consultation) |
| City of Port Moody, BC | 100% EV Ready | TBD |
| District of Squamish, BC | 100% EV Ready | TBD |
| City of Surrey, BC | 100% EV Ready | 20% EV Ready |
| Township of Langley, BC | 1 EV Ready / dwelling | TBD |
| District of Saanich, BC | 100% EV Ready | Varies |
| City of Nelson, BC | 1 EV Ready / dwelling | 10% EV Ready |
| District of West Van., BC | 100% EV Ready | TBD |
| City of Victoria, BC | 100% EV Ready | 5% EV Ready |
| City of Toronto, ON | Tier 1 TGS – 25%<br>Tier 2 TGS – 25%<br>Future – in EV Strategy<br>100% EV Ready | 20% EV Ready |
| Ville de Laval, QC | 50% EV Ready | |
| Previous Ontario Building Code (rescinded) | 20% EVSE | 20% EVSE |

# EV CHARGING PERFORMANCE REQUIREMENTS

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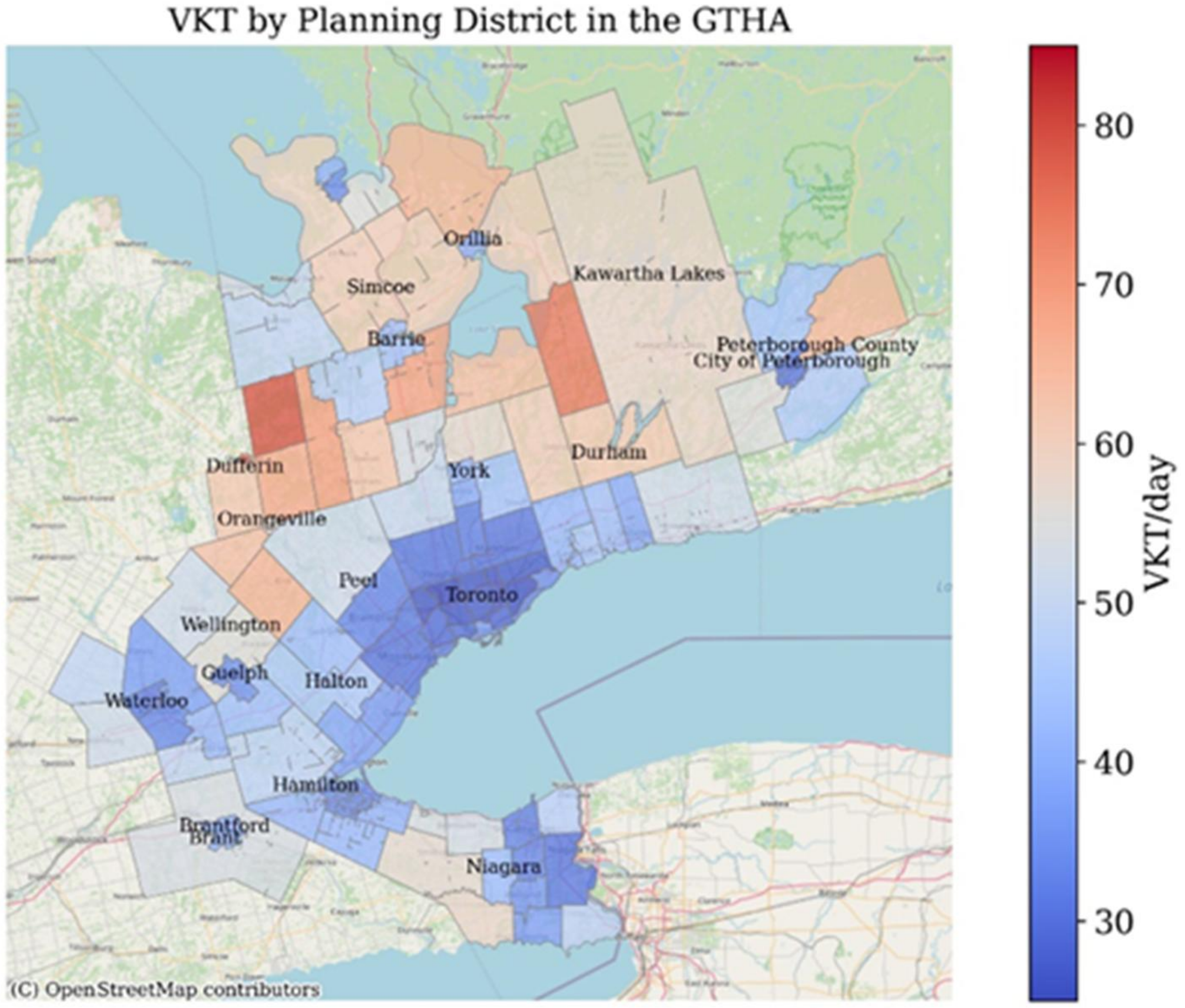
# HOW MUCH POWER DO EVs NEED TO CHARGE?
## It (largely) depends on how far they drive…




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 |

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# 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 |

# COSTING STUDY

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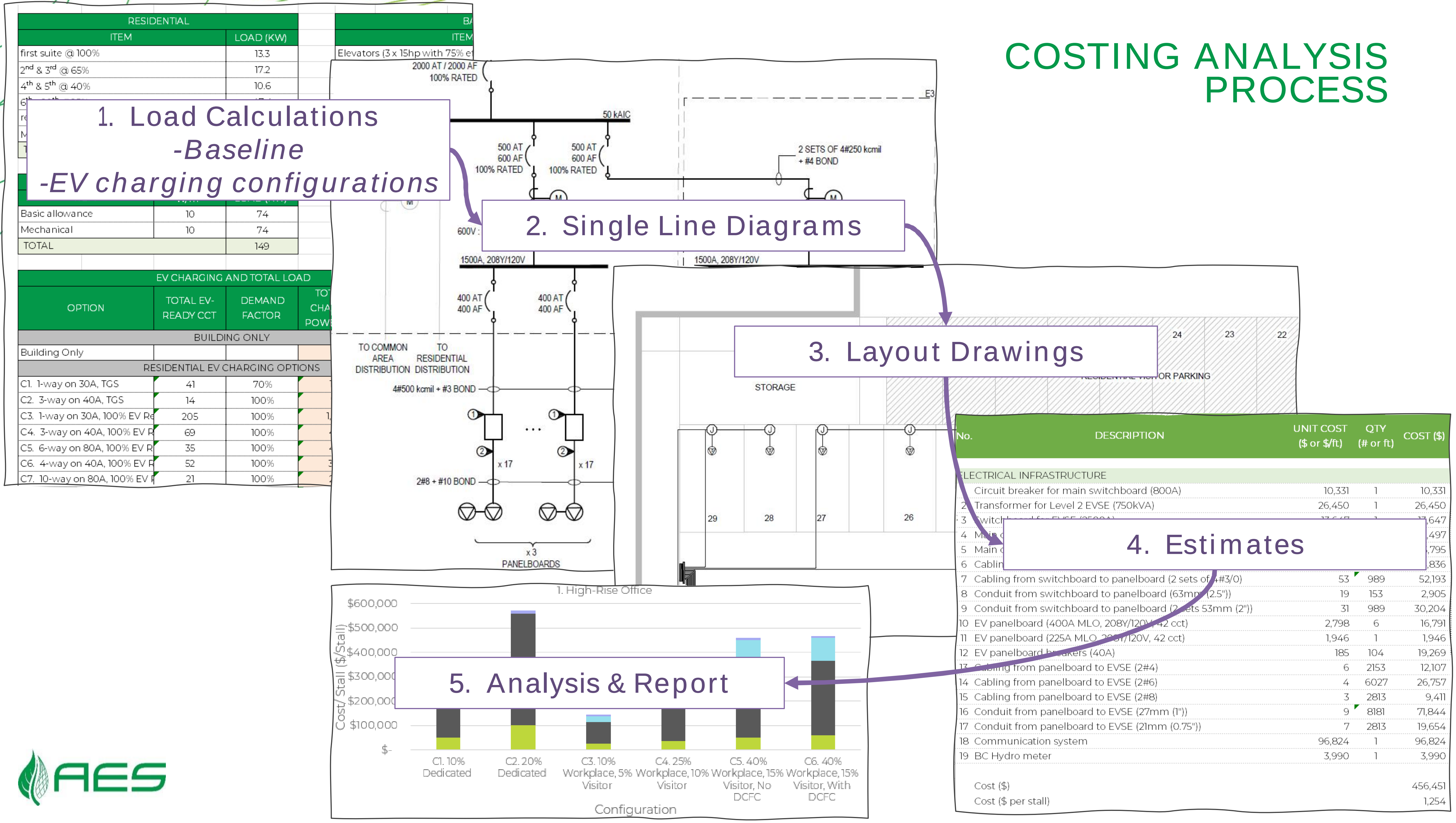
# COSTING ANALYSIS PROCESS

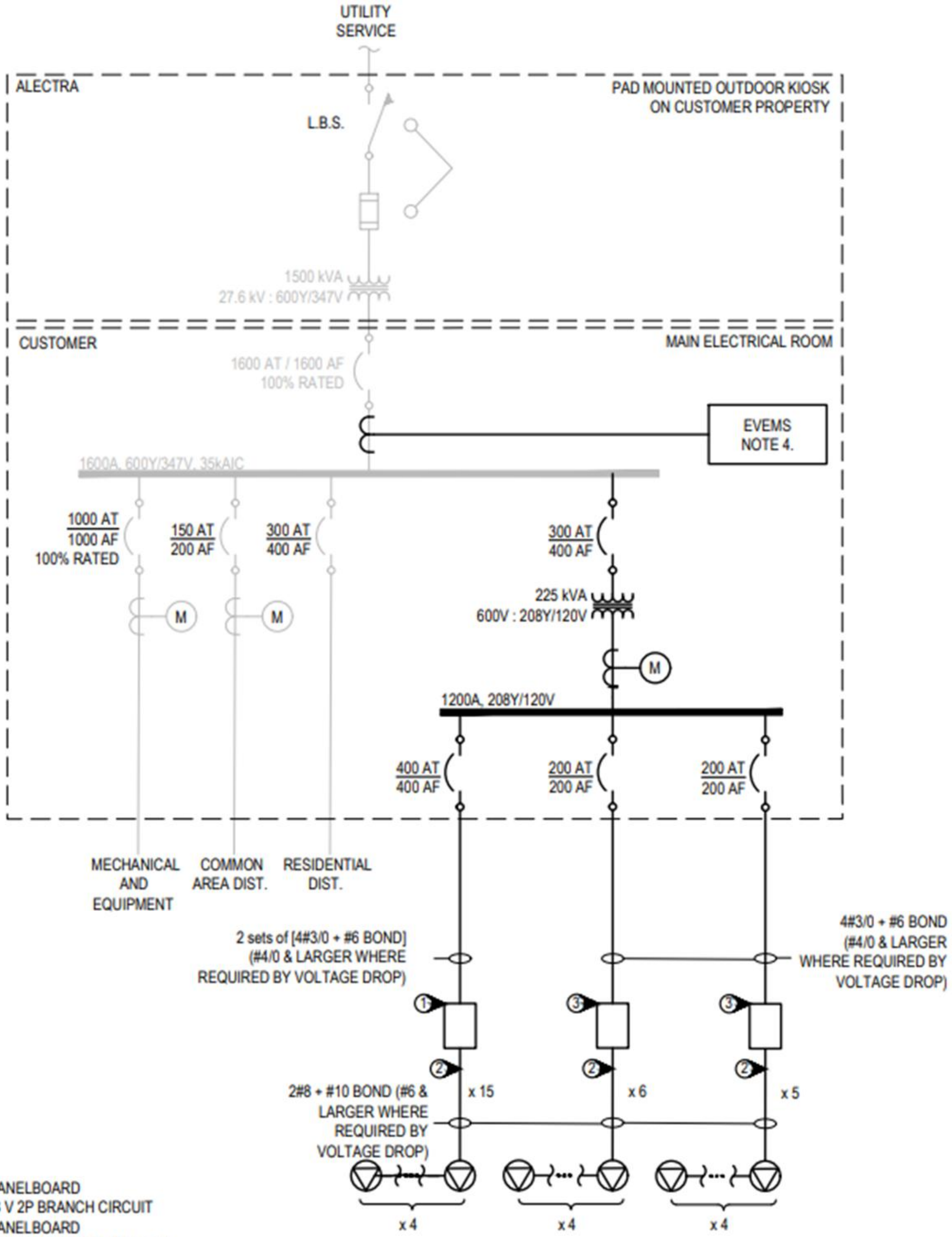


# RESIDENTIAL BUILDING ARCHETYPES

| | | | Parking Stalls | |
|---|---|---|---|---|
| Archetype | Storeys | Number of Units | 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 |

# 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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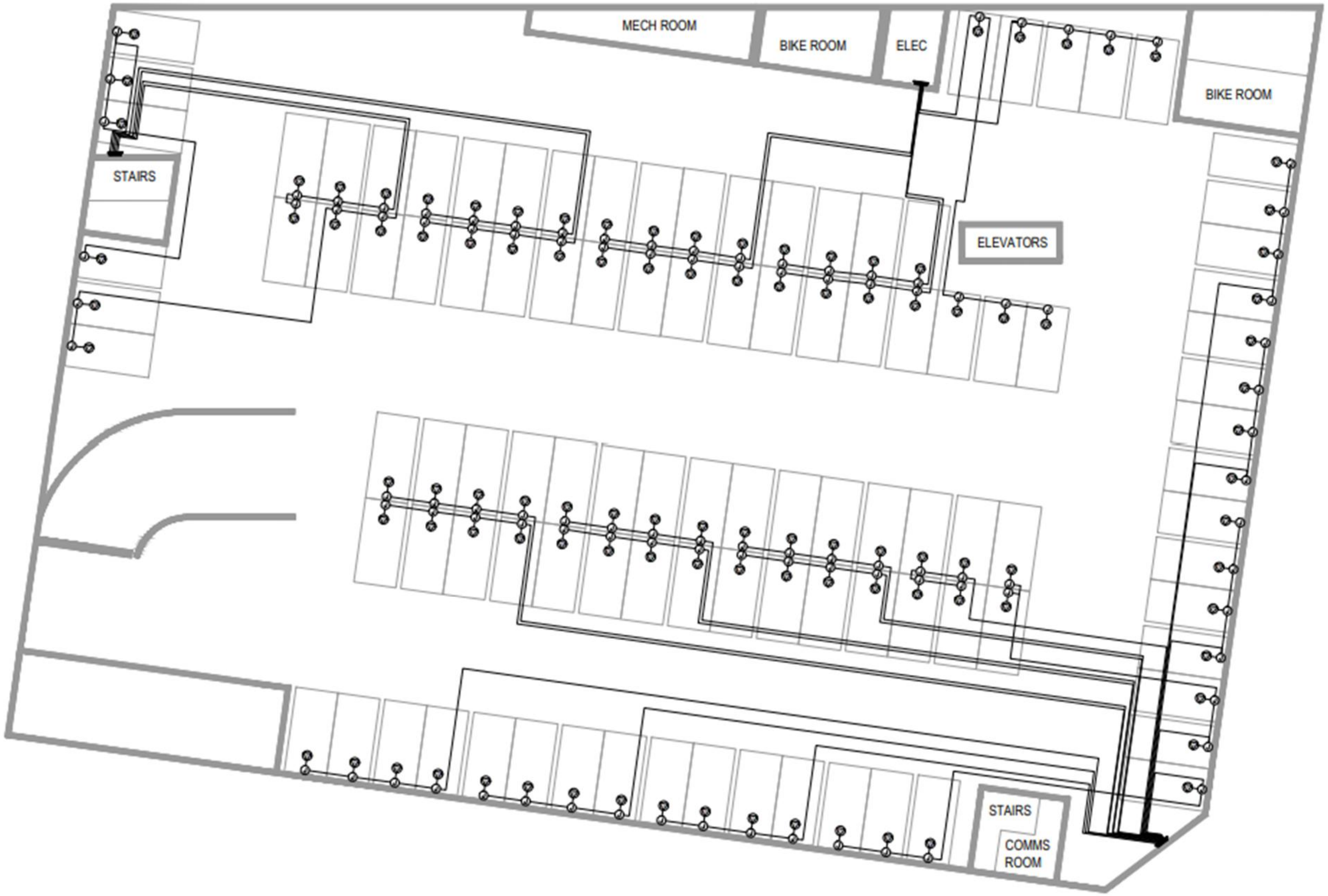
# EXAMPLE DESIGN – MID-RISE SCENARIO C7

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

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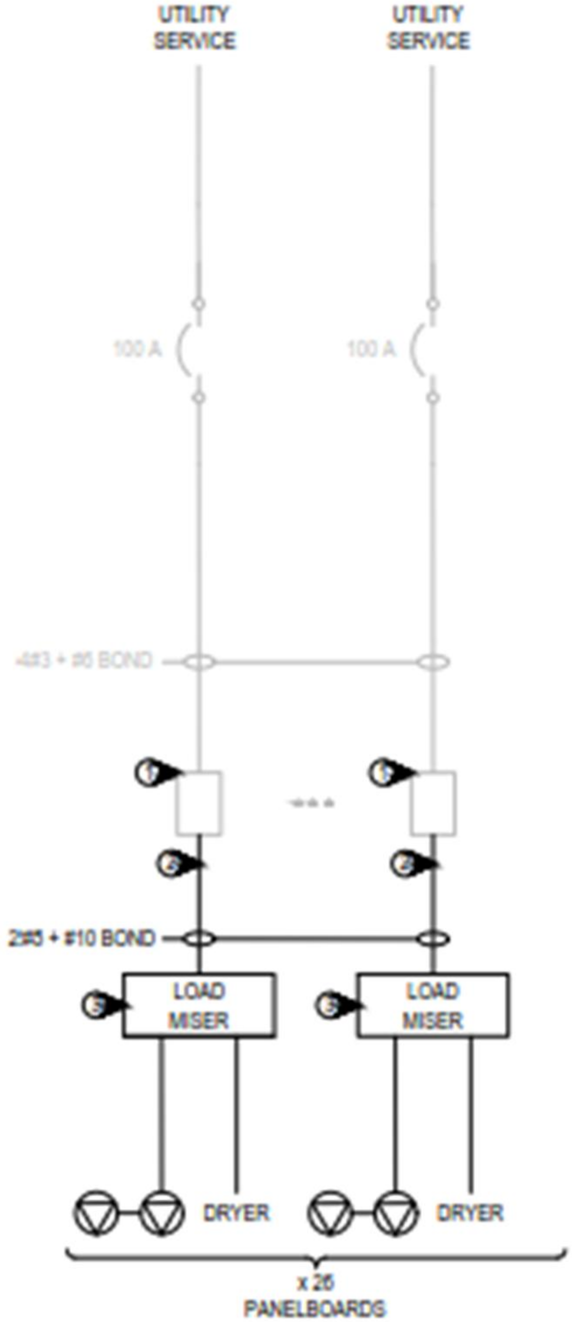
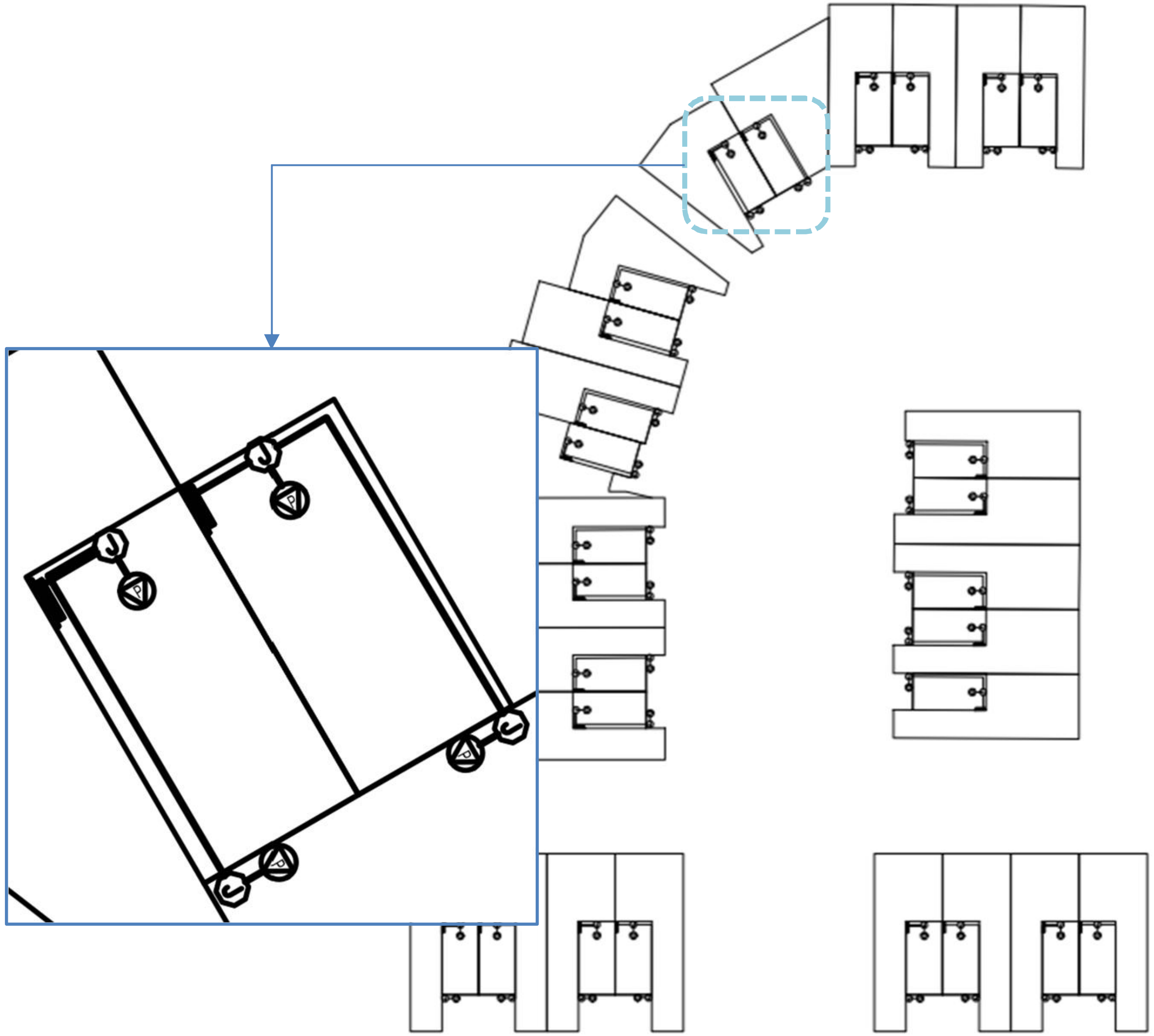
# EXAMPLE DESIGN – TOWNHOUSE C3 2-SHARE ON 40A BRANCH CIRCUITS, WITH LOAD SWITCHING (LOAD MISER)




KEYNOTES:

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



# 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 |

# HIGH 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 | 10 | 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 | 10 | 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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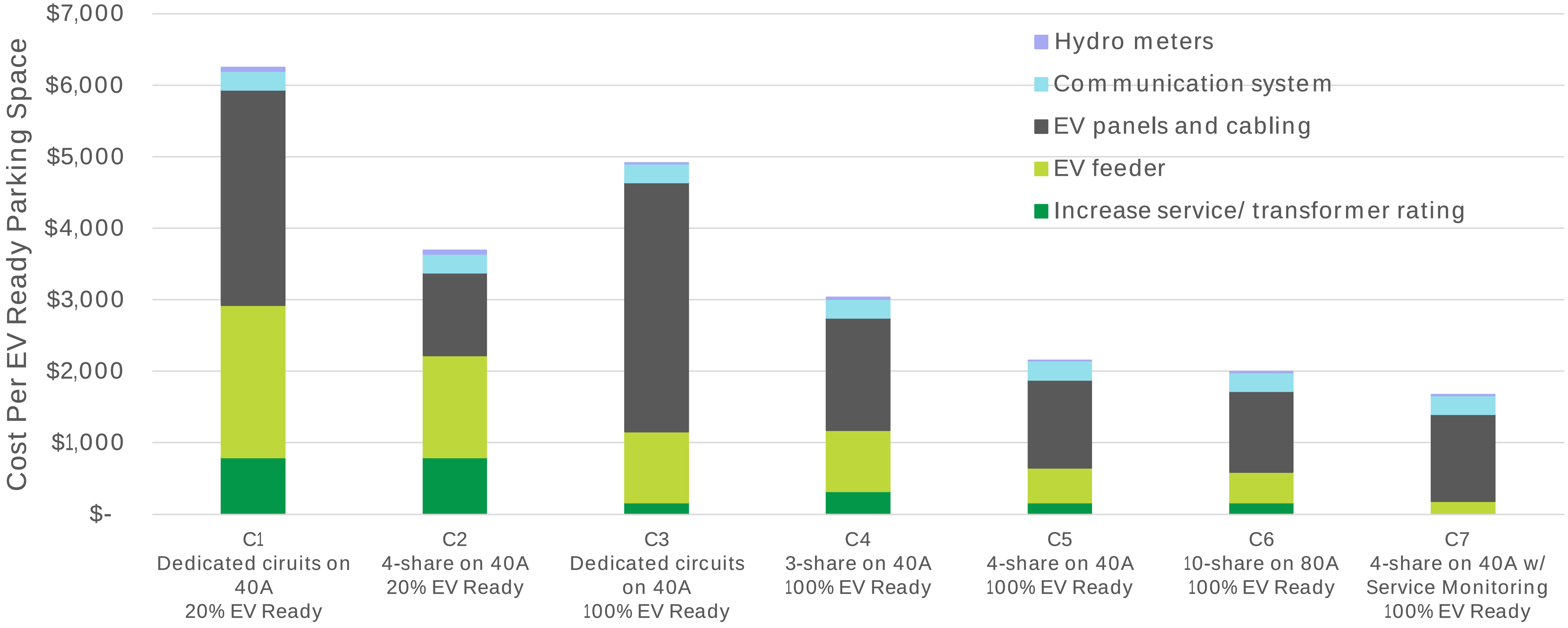
# RESULTS
## HIGH RISE (ALECTRA TERRITORY)
## COST PER EV READY PARKING SPACE

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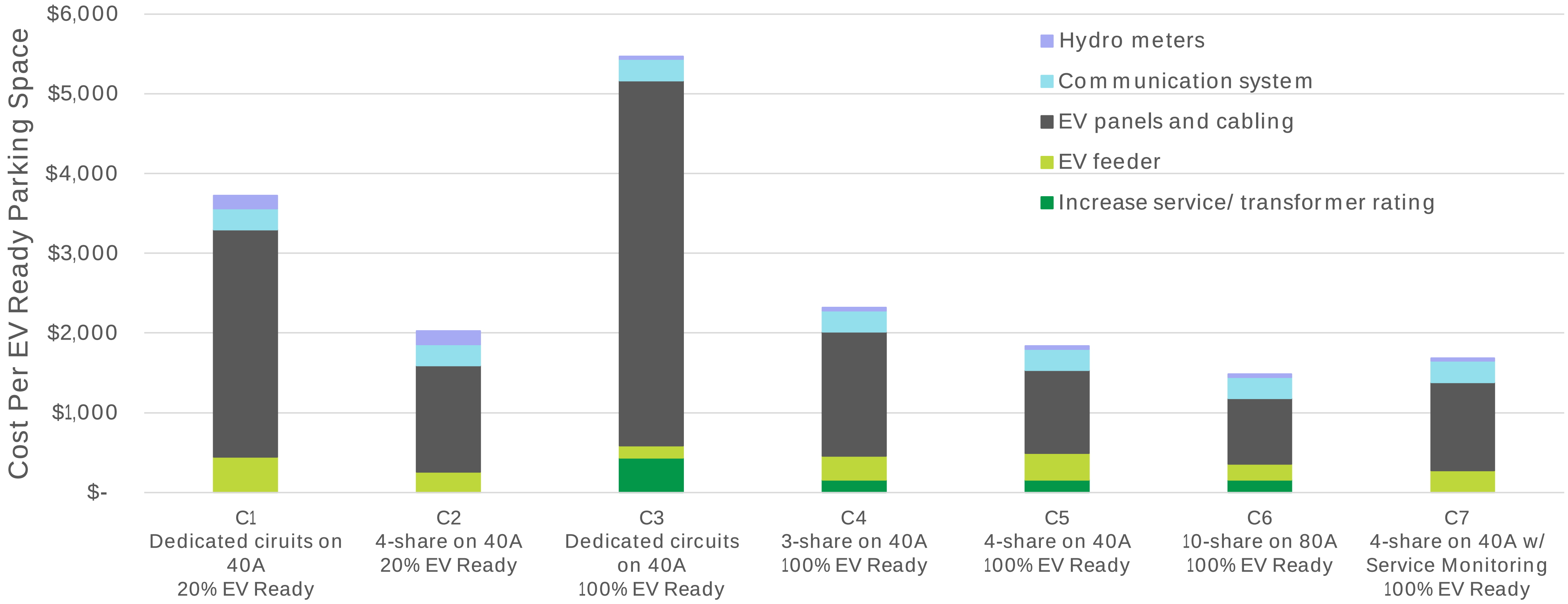
# RESULTS
## MID RISE
## COST PER EV READY PARKING SPACE

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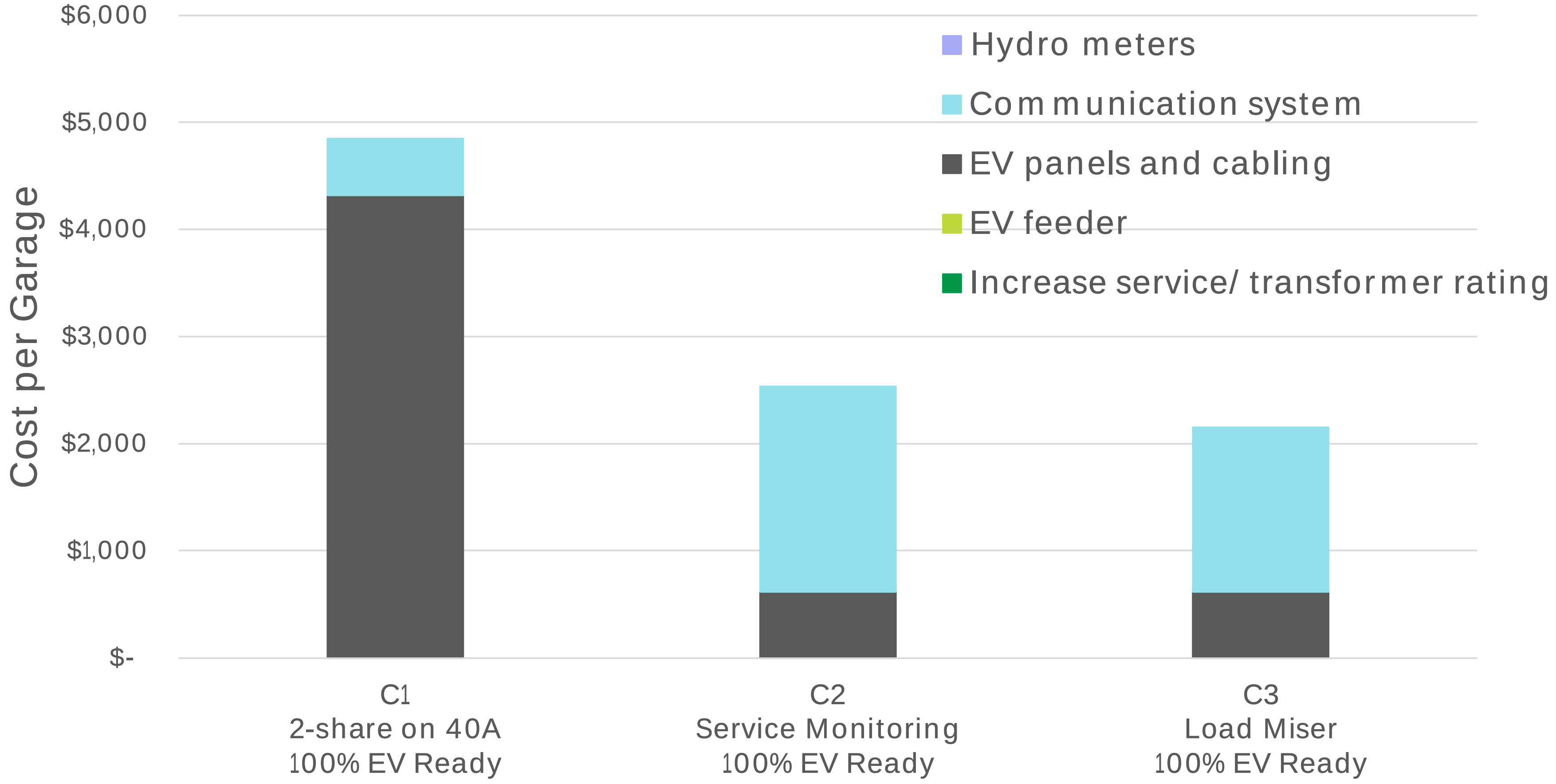
# RESULTS
## TOWNHOUSE
## COST PER GARAGE

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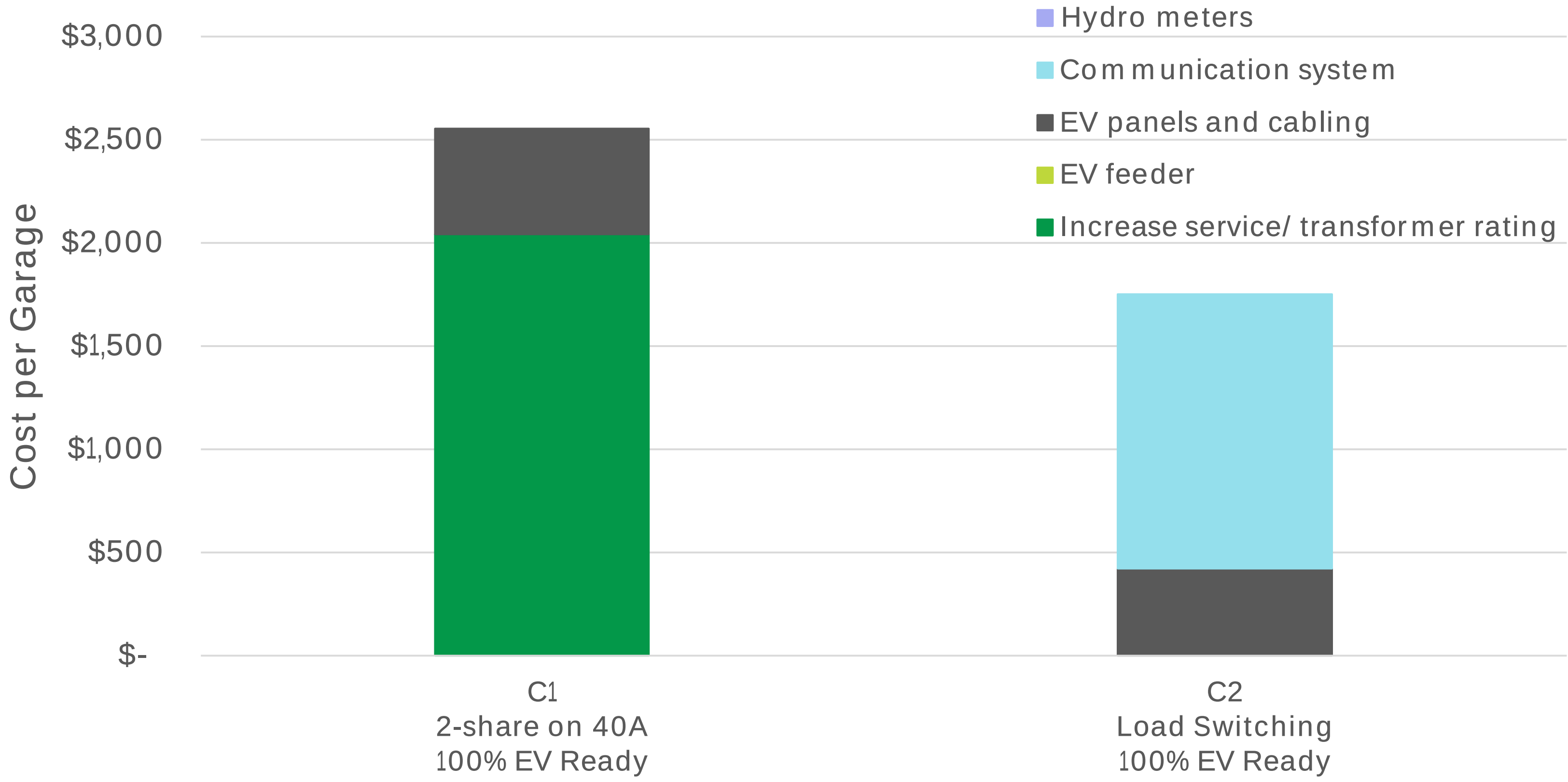
# RESULTS
## SINGLE FAMILY SUBDIVISION COST PER GARAGE

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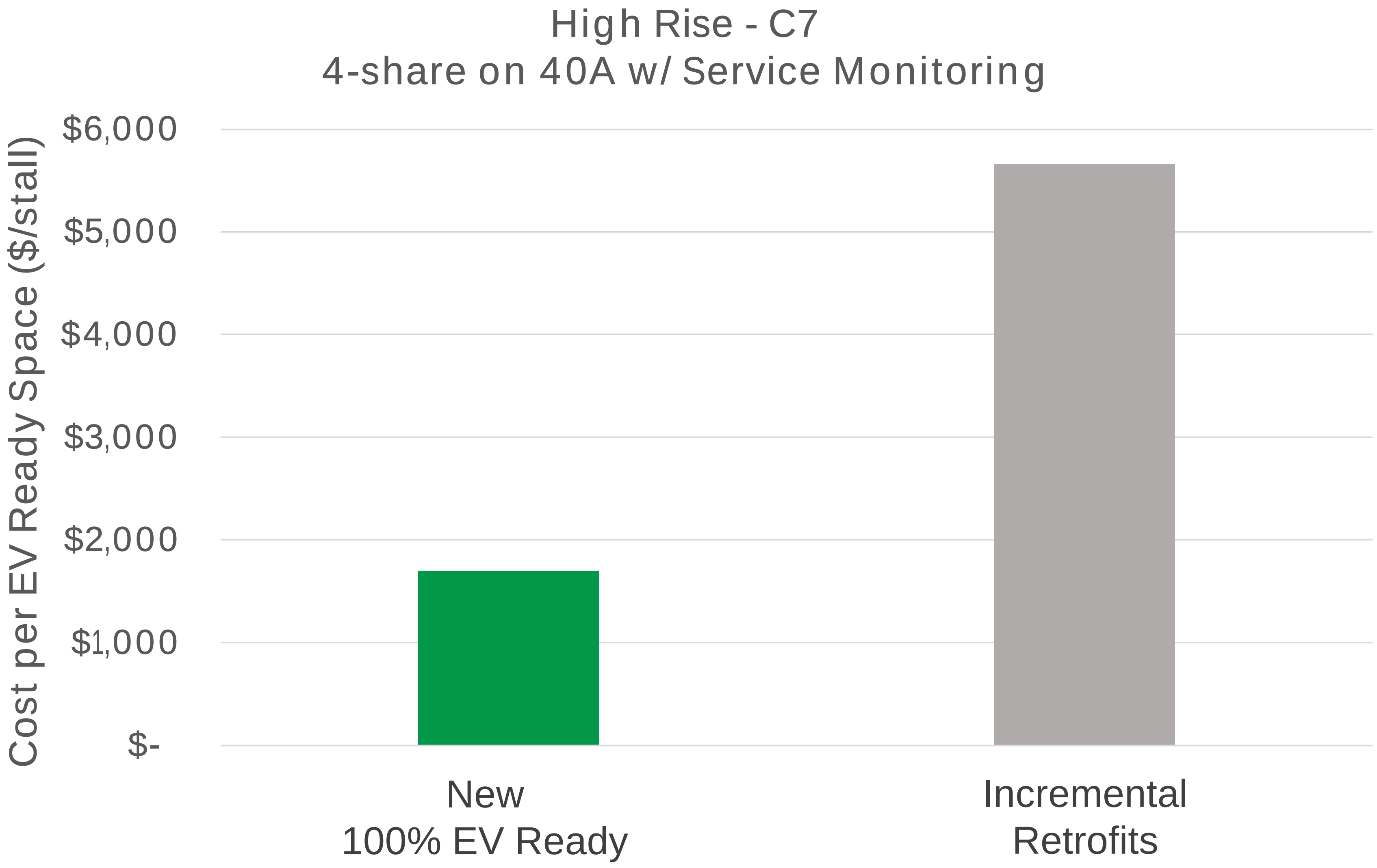
# COST OF EV READY NEW CONSTRUCTION VERSUS INCREMENTAL RETROFITS
## Example – High Rise

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# CONCLUSIONS FROM COSTING STUDY

- 100% EV Ready can be achieved for ~$1500 per parking space (apartments w parkade), or per garage (ground-oriented w private onsite parking attached to unit) with conservative assumptions
  - Design for EVEMS
- Much lower cost and complexity than retrofitting EV Ready parking

# THANK YOU!

brendan.mcewen@aesengr.com

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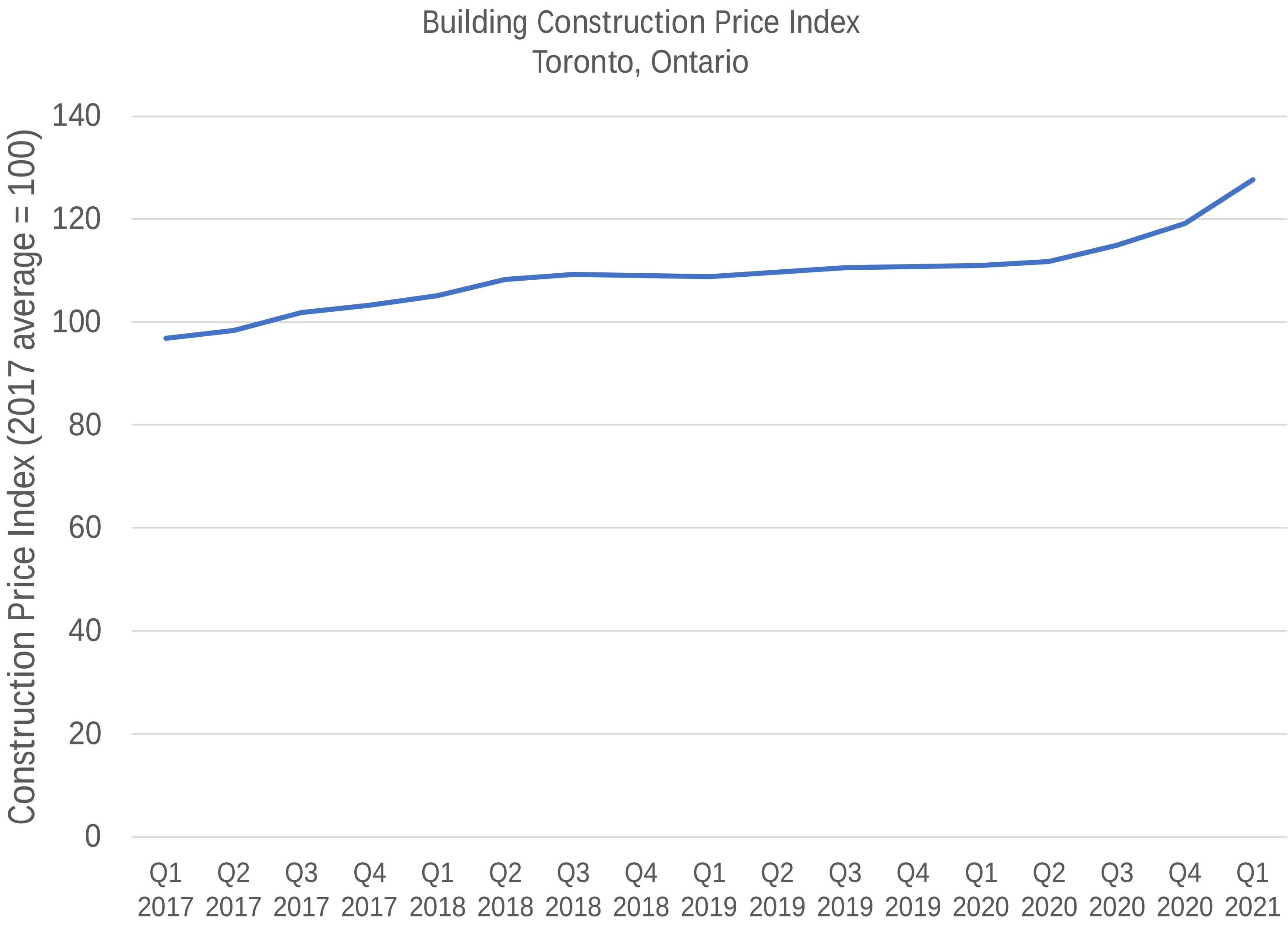
# OTHER CONSIDERATIONS

# 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.**

# CONSTRUCTION COSTS

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**Source:** Stats Canada.

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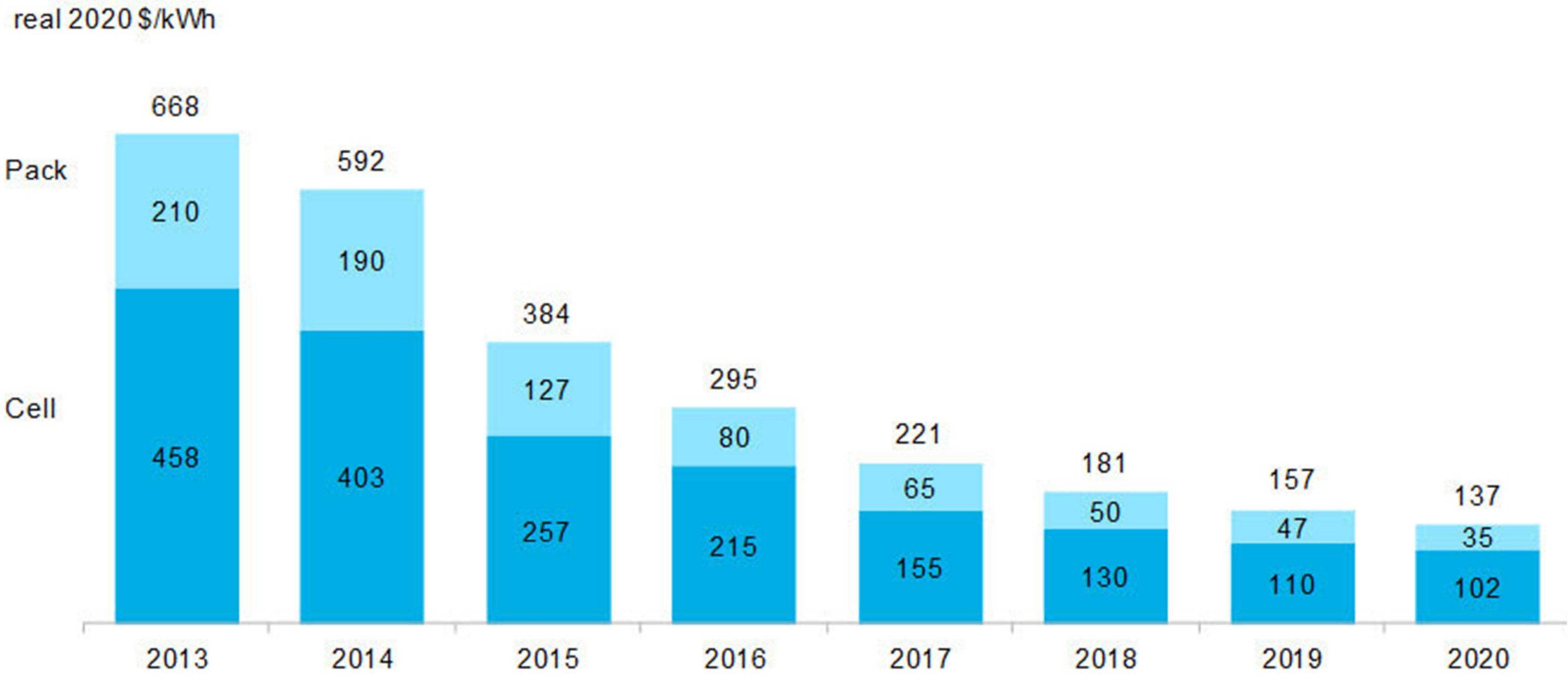
# EV'S Li-ION BATTERY COSTS ARE DECLINING




*Source: BloombergNEF*

# EV CHARGING PERFORMANCE REQUIREMENTS

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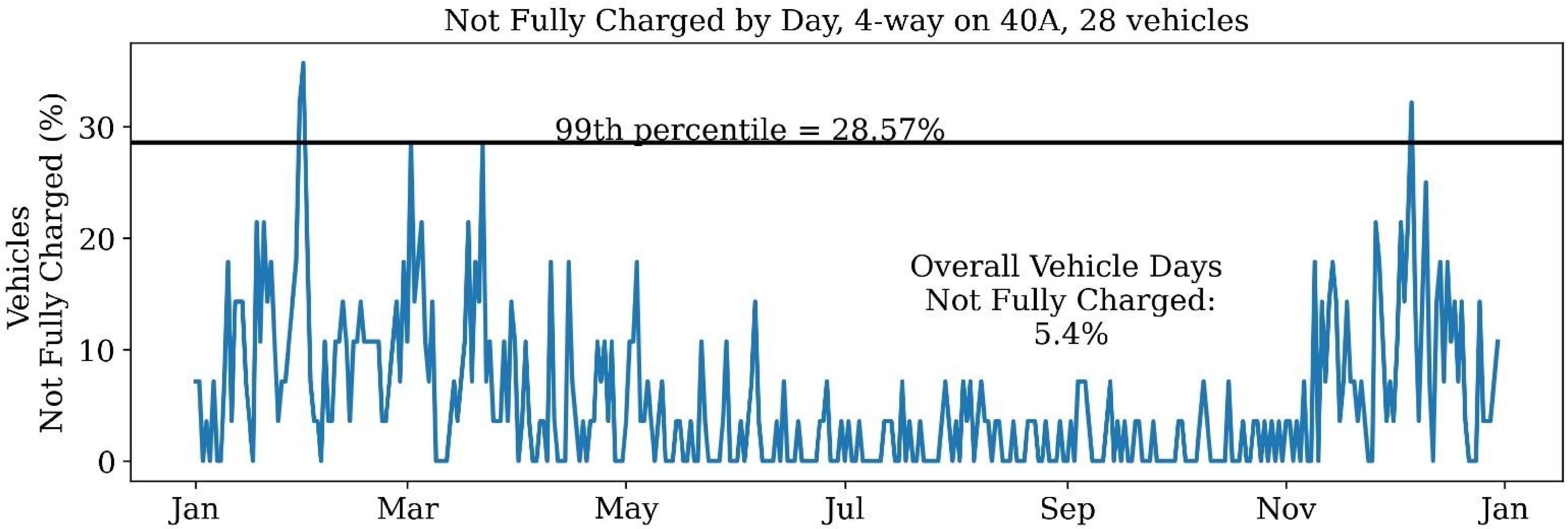
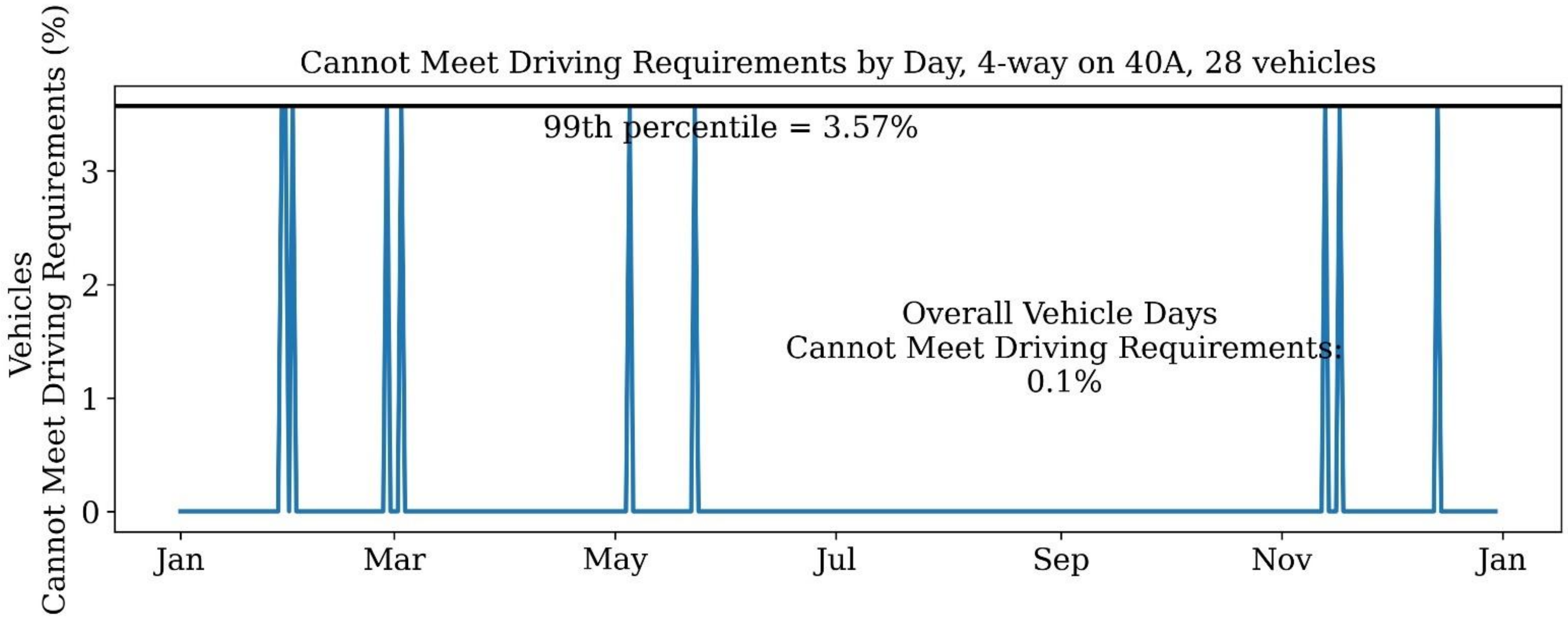
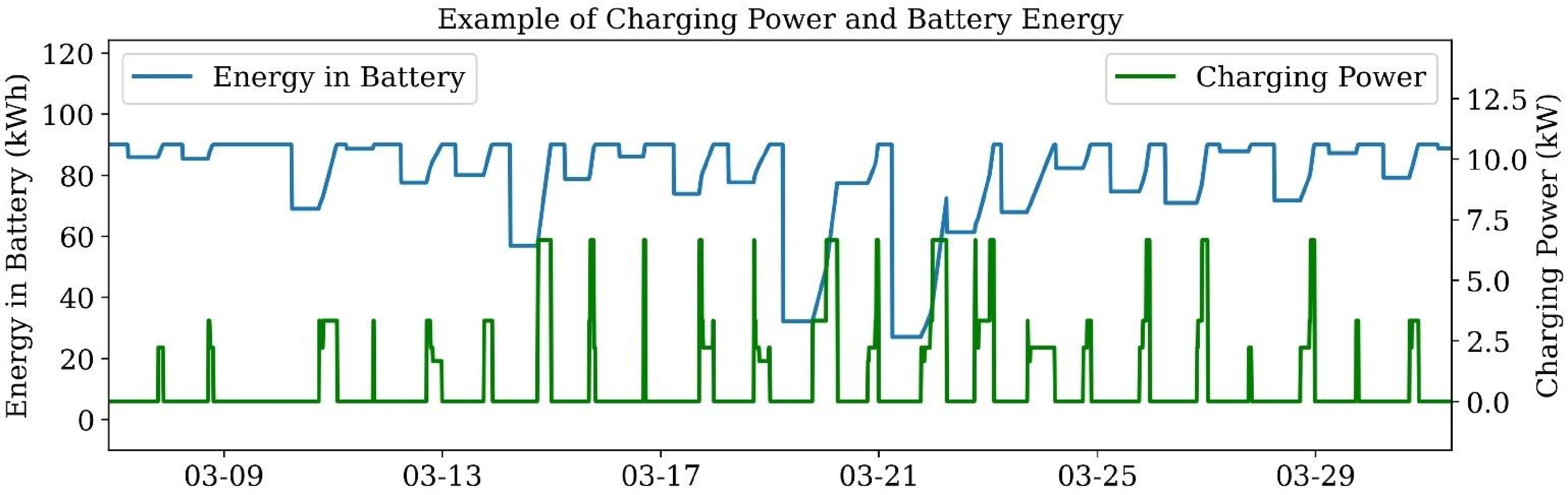
# PERCENT OF VEHICLES THAT ARE NOT FULLY CHARGED THROUGHOUT A YEAR OF SIMULATIONS



# 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.



# 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 |

AES

DESIGNING A BETTER TOMORROW